MAKERERE UNIVERSITY

FISHERS' PERCEPTION ON LIVELIHOOD STRATEGIES, ADAPTATION AND MITIGATION MEASURES TO COPE WITH CHANGES IN CLIMATE VARIABLES AROUND LAKE WAMALA, UGANDA

By

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Declaration

I Musinguzi Laban, declare that this study is original and has not been submitted for any other degree award to any other University before

Signed.. Date 12/01/2015....................................

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Dedication

I lovingly dedicate this dissertation to my parents, Mr. Abel Ndagije and Mrs. Mauda Ndagije for their efforts and sacrifices for me to acquire a Master of Science degree.

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List of abbreviations

FAO:	Food and Agriculture Organization of the United Nations
GDP:	Gross Domestic Product
IPCC:	Intergovernmental Panel on Climate Change
MAAIF:	Ministry of Agriculture, Animal Industry and Fisheries
NaFIRRI:	National Fisheries Resources Research Institute
NOAA:	National Oceanic and Atmospheric Administration.
UNEP:	United Nations Environment Programme
USAID:	United States Agency for International Development

Abstract

Fisheries support livelihoods but are threatened by climate variability and change which intensified since the 1970s. This study used quantitative and qualitative methods to determine the extent to which fishers around Lake Wamala in Uganda were copying with perceived changes in climate variables and the impacts on their livelihoods, to generate knowledge to enable the fishers increase resilience and sustain their livelihoods. Fishers were aware of changes in climate manifested by unpredictable seasons, floods and droughts. Fishing was the main livelihood activity. The African catfish had replaced Nile tilapia as the dominant fish species. There was damage and loss of gear, boats, landing sites and lives, and changes in fish catches and sizes, income and fish consumption during the perceived floods and droughts. The fishers adapted to the changes through increasing time on fishing grounds and changing target species and fishing gears but innovative ones diversified to high value crops and livestock which increased their income beyond what was earned from fishing thus acting as an incentive for some of them to quit fishing. Diversification to non-fishery activities as a form of adaptation was enhanced by membership to social groups, weekly fishing days, fishing experience and age of fishers but its benefits were not equally shared among men and women. Mitigation measures included planting trees, mulching gardens and protecting wetlands. Adaptation and mitigation measures were constrained by limited credit, awareness and land. The required interventions included improving access to credit, irrigation facilities and appropriate planting materials and raising awareness. The study showed that the fishers were aware of changes in climatic variables and the impacts on their livelihoods. There were also adaptation and mitigation measures practiced by the fishers which if promoted and their constraints addressed, could increase resilience of fishers to climatic change and sustain their livelihoods.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Fish contributes about 15% of average global *per capita* animal protein intake for 4.3 billion people (FAO, 2014). In Uganda, fish provides >50% animal protein for the population, with a *per capita* consumption of 6 kg. It contributes 12.5% to agricultural GDP and 2.5% to national GDP, employs about 1.2 million people and generates over $150 million in export earnings (MAAIF, 2012). Fisheries resources are however threatened by over-exploitation, habitat degradation, pollution, invasive species, parasites and diseases and more recently, the increasing variability and change in climate. While the other threats have received considerable attention, climate variability and change, which intensified since the last three decades of the 20th century (IPCC, 2013) has received limited attention.

Globally, climate variability and change has manifested by average increase in temperatures by 0.62°C by the end of 2013, well above pre-industrial levels (NOAA, 2013). Changes in temperature contribute to changes in water balance, stratification, water circulation, nutrient dynamics and dissolved oxygen levels in aquatic systems (Lorke et al. 2004; Verburg & Hecky, 2009; Tierney et al. 2010). These in turn affect fishery productivity processes, fish yield and consequently livelihoods of fishers (IPCC, 2007; Cheung et al. 2009; Brander, 2010; Perry et al. 2009). Livelihoods of fishers are comprised of components like fishers themselves, fish stocks, fishing gears, landing sites, education, health, savings, credit and social networks (Allison and Ellis, 2001). The impacts of climate variability and change on livelihoods are manifested through effects of extreme climatic events like increased rainfall, floods and droughts on the livelihood components, related activities and their outcomes (Balgis et al. 2005; Westlund et al. 2007). Evidence of the impacts of such events has accumulated since the time when climate variability and change intensified. For example, the number of fish species in Lake Chad decreased from 40 to 15 between 1971 and 1977 following a drought period (Leveque, 1995). Fish yield on Lake Chilwa was highly correlated with lake level and decreased to zero in 1996 following drying up of the lake (Allison et al. 2007; Njaya et al. 2011). The yield of Kapenta (*Limnothrissa miodon* Boulenger) in Lake Kariba decreased at an average rate of 24 tons per year between 1974 and 2003 with changes in rainfall and water levels (Ndebele-Murisa et al. 2011). Although Marshall (2012) largely attributed the decrease to fishing, climate variability and change appears to have contributed (Ndebele-Murisa et al. 2011).

In Uganda, the contribution of a once uneconomically valuable small cyprinid species, *Rastrineobola argentea* Pellegrin (locally known as Mukene) has increased to 40-80% of commercial catches in lakes Victoria, Kyoga and Albert. This is in line with the prediction by FAO (2010) that climate variability and change will shift fisheries to small, fast growing opportunistic species. Floods, droughts and storms associated with changes in climate variables have destroyed landing sites, boats and gear and have disrupted fishing activities, led to loss of lives, displaced lakeside communities and caused economic loses (Aiken et al. 1992; Broad et al. 1999; Jallow et al. 1999; Westlund et al. 2007; Birkmann & Fernando, 2008; Trotman et al. 2009; Ogutu-Ohwayo et al. 2013).

Various studies have reported that fishers adapted to the impacts of climate variability and change in various ways. On Chilwa, some fishers diversified to farming and pastoralism while others migrated in response to the decrease in fish catches that followed the drop in lake levels (Allison et al. 2007; Njaya et al. 2011). On lakes Victoria, Kyoga and Albert, fishers shifted from using gillnets to mosquito seine nets with increases in the Mukene fishery (Ogutu-Ohwayo et al. 2013). However, adaptations are mostly location-specific depending on the types of impacts and the people's ability to respond to climate extremes. There is therefore need to generate location-specific knowledge to guide development of applicable adaptation and mitigation measures to enable communities affected by the influence of the increasing variability and change in climate to increase their resilience and sustain their livelihoods.

This study aimed at generating such knowledge for fisher communities around Lake Wamala. It examined perception of fishers to climatic events, how they associated the climatic events with livelihoods, adaptation and mitigation measures to the perceived climatic events, constraints to adaptation and mitigation measures and required interventions. It was conducted among fishers around Lake Wamala in Uganda which is suitable for such a study because it has manifested changes in water levels, fish species composition and fish yield associated with changes in climate variables especially rainfall.

1.2 Problem statement

Climate variability and change has intensified since the 1970s and is expected to worsen in future. This is expected to affect important natural resources such as fisheries by influencing fishery productivity processes and fish yield. This will in turn affect the livelihoods of fishers who depend on them, necessitating response through adaptation and mitigation measures that will enable the fishers to cope with the impacts of climate variability and change. Lake Wamala experienced changes in its fisheries in relation to changes in climate variables especially temperature and rainfall and the impacts of these changes on the livelihoods of fishers around the lake were not well known. Further still, the extent to which the fishers adapted or provided mitigation measures had not been ascertained. This put their livelihoods in danger and there was need for knowledge to develop appropriate adaptation and mitigation measures to enhance resilience of the fisher to the increasing climate variability and change.

1.3 Objectives of the study

1.3.1 Overall objective

The overall objective of this study was to determine the extent to which fishers of Lake Wamala are copying with perceived changes in climate variables and their impacts on livelihoods of the fishers.

1.3.2 Specific objectives

The specific objectives were to assess;

1. Perception of fishers to climate variability and change;
2. Demographic characteristics and livelihoods of fishers around Lake Wamala;
3. Perceived impacts of climate variability and change on the livelihoods, adaptation and mitigation measures, related constraints and required interventions around Lake Wamala.

1.4 Research Questions

1. How have climate variables changed around Lake Wamala and what are the perceptions of fishers on these changes?
2. What are the demographic characteristics and livelihoods of the fishers around the lake?

3. How are the changes in climate variables associated with the livelihoods of fishers around the lake?
4. How have the fishers adapted and how have they contributed to mitigation of climate variability and change?
5. What are the constraints to adaptation and mitigation measures and how can these be overcome?

1.5 Justification

This study contributes to an understanding of how the livelihoods of fishers are impacted by perceived floods and droughts and how the fishers can respond through adaptation and mitigation measures. It also generated knowledge on constraints to adaptation and mitigation, and required interventions. The knowledge will guide development of adaptation and mitigation measures to enable fishers sustain their livelihoods under the increasing climate variability and change. Fisher communities need the knowledge to develop alternative livelihood options to increase their resilience and cope with impacts of climate variability and change. This knowledge will also be used by governments and other development agencies to prioritize development interventions among fishers and related communities dependent on other vulnerable sectors.

The study contributes to international, regional and national policies concerned with food security, poverty and sustainable development by providing knowledge that can enhance adaptation and mitigation measures. The study contributes to the provisions of the United Nations Framework Convention on Climate Change and its Kyoto Protocol as it advanced knowledge that can enhance mitigation measures. It contributes to the Africa-EU strategic action plan and the East Africa Community Policy on Climate Change as the knowledge can be up scaled to other areas including the African Great Lakes region. In Uganda, it contributes to the Uganda National Development Plan (NDP), the Development Strategy and Implementation Plan (DSIP) of Ministry of Agriculture, Animal Industry and Fisheries, the Uganda National Policy on Climate Change and the Uganda National Adaptation Program of Action (NAPA).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Variations in climate variables and community perceptions of the variations

Climate includes variables such as temperature, rainfall and wind speed. Climate change involves extreme shift in these climate variables due to natural or human factors. Climate change is intensifying as manifested in rising temperatures, fluctuations in rainfall, floods, droughts, and wind storms (IPCC, 2013). In Uganda, it has been manifested by increased frequency of drought (Government of Uganda, 2007). Chapman and colleagues (2005) and Hepworth & Goulden (2008) predicted that temperatures in Uganda will increase by 1.5^0C by 2030 and 4.3^0C by 2080. These projections indicate that Uganda will experience climate related impacts on natural and social systems, including livelihoods as they are near or beyond the 2^oC mark beyond which climate variability and change is expected to cause disastrous events (Hansen et al. 2013).

The increase in temperature will result in increased rainfall which will in turn result in increased frequencies and magnitudes of floods (Frederick & Gleick, 1999). The increase in temperature will result into increased frequencies and magnitudes of droughts where rainfall is relatively variable (Hudsen, 1964). These will increase risks to natural systems and human communities (IPCC, 2001). Water levels in Ugandan water bodies have fluctuated due to changes in the climate variables. For instance, Lake Wamala covered ~250 km^2 in 1980s and the area shrunk to about half that size in early 1990s (UNEP, 2009).

All over the world, knowledge of changes in climate is increasing among scientists and household communities (Anderegg, 2010; Haque et al. 2012). In Uganda, farming communities perceive changes in weather patterns in terms of erratic rainfall, poor rainfall distribution and little rainfall (Mubiru et al. 2009). This knowledge is important as response to climate variability and change by adaptation and mitigation needs recognition that it is occurring (Downing, 1996).

2.2 Demographic characteristics of fisher communities

Fisher communities are characterized by high levels of poverty, high population, migration, unemployment and low education levels (Branch et al. 2002). These and other characteristics such as age, gender, ethnicity and membership to social groups affect the capacity of these communities to adapt to climate variability and change (Scheraga & Grambsch, 1998). For instance, education is associated with the ability to access and utilize information and adoption of technologies (Daberkow & McBride, 2003) and therefore enhances adaptation. Therefore demographic characteristics need to be considered when addressing impacts of climate variability and change and in development of adaptation and mitigation measures.

2.3 Livelihood characteristics of fishers

Livelihoods comprise the capabilities, assets and activities required for peoples' means of living (Department for International Development, 1999). Assets are capitals that people draw upon to make a living and are categorized into human, social, natural, financial, and physical. Assets among fishing communities include fish (natural), fishing gear, boats (physical), social groups (social), revenue (financial) and fishers lives (human). Activities involve the diverse ways people access and use the assets and these include fishing, fish processing and trading by fisher communities. People are able to cope with and recover from stresses and shocks including climate variability and change when their livelihoods are sustainable (Chambers & Conway, 1991).

Fishing is the main source of livelihood of fishing communities (Aldon et al. 2010) and supports 660–820 million people, or about 10–12% of the world's population (FAO, 2014). In Uganda, fishing supports 1.2 million people who directly or indirectly depend on fisheries. Other activities that the fishers are involved in include crop and livestock agriculture, trade and formal and informal employment.

Fishers are predominantly characterized by high poverty levels (Branch et al. 2002) and therefore have less capacity to mobilize resources to overcome shocks. Poverty and limited access to other resources makes them less likely to exit the declining fisheries (Cinner et al. 2009). Consequently, they may remain in poverty. However, planned adaptation and mitigation measures directed at the fishers can promote diversified livelihoods. This requires an understanding of their livelihood and how they are impacted by climate variability and change and the available adaptation and mitigation options and how they can be addressed.

2.4 Effect of climate variability and change on aquatic productivity and fisheries resources

The intensification of climate variability and change (IPCC, 2013) will impact natural resources like fisheries that are sensitive to climate (Allison et al. 2005). Fisheries are affected by decrease in average river runoff, shifts in precipitation and consequent change in the timing of peak river flows and changes in flood and drought frequency and intensity (Milly et al. 2005). Aquatic productivity processes are affected through effect on nutrient and dissolved oxygen circulation, primary and secondary production, alteration in food-webs, and shifts in fish communities and fisheries. Evidence of impacts of climate variability and change on fisheries resources has been observed with changes in fish species diversity, size and composition (Munday et al. 2008; Pratchett et al. 2008), species distribution (Perry et al. 2005), possible species extinction (Cheung et al. 2009) and reduced productivity (O'Reilly et al. 2003; Vollmer et al. 2005; Allison et al. 2007).

FAO (2010) has predicted that climate change will shift fisheries to smaller, faster growing, opportunistic less valuable species that can adapt fast to the changing environment. These will bring changes in aquatic productivity processes and fisheries production (Cheung et al. 2009; Brander, 2010; Drinkwater et al. 2010) that will ultimately affect the livelihoods of the people dependent on fishery resources.

2.5 Effect of climate variability and change on livelihoods of fishers

Climate variability and change affects various livelihood assets, activities and outcomes (Balgis et al. 2005) of fisher communities who depend on the climate sensitive fisheries (Allison et al. 2005). For example, the recession of Lake Victoria water levels caused a decrease in fish catches affecting livelihoods of fisher communities around the lake (Rubaru et al. 2012). Impact of climate variability and change on availability of fish products, revenues, harvesting strategies, processing and marketing will disrupt fishing operations and affect the fisher communities. Severe weather conditions damage assets and infrastructure such as landing sites, boats and gear (Jallow et al. 1999), disruption of marketing systems and loss of lives.

2.6 Adaptation measures to climate variability and change

Adaptation is an important response option to climate variability and change (Fankhauser, 1996). Adaptation involves adjustments in ecological, social, or economic systems to reduce the vulnerability of communities, regions, or activities. Fisher communities can adapt by migrating, intensifying fisheries activities, shifting to other species, exiting fishing or diversifying to other livelihoods (Allison et al. 2007; Coulthard, 2009). Human systems have the capacity to adapt (Mendelsohn & Neumann, 1999) but their adaptive capacity can be related to demographic variables such as age, gender, ethnicity, educational level, and health (Scheraga & Grambsch, 1998). However, limited information and access to resources limit fisher's capacity to adapt, necessitating need for planned adaptation (Fankhauser et al. 1999; Bryant et al. 2000).

2.7 Mitigation of impacts climate variability and change

Effective mitigation of impacts climate variability and change is necessary to reduce its impact on water resources (IPCC, 2007). Mitigation includes measures to reduce or prevent emission of the greenhouse gases (IPCC, 2007) including improving efficiency of vessels, changing fishing behavior and planting trees. It is the simplest and most cost-effective strategy compared to adaptation (Daw et al. 2009) but limited knowledge is a challenge to its effectiveness (Smith et al. 2007).

2.8 Constraints to adaptation and mitigation and required interventions

A number of factors can hinder the capacity of communities to adapt and mitigate the impacts of climate variability and change on livelihoods (Scheraga & Grambsch, 1998). These need to be addressed by government and development agencies and the communities themselves to enable them adapt to and cope with impacts of climate variability and change and sustain their livelihoods. Some of these include limited awareness, poverty, inadequate law enforcements, and lack of capital.

2.9 The fishery of Lake Wamala and the need to develop planned adaptation and mitigation measures

The mean depth of the Lake Wamala has historically fluctuated between 1.5 and 4.5 m and its area between 100 and 250 km² depending on rainfall. Satellite images showed that the lake area shrunk between 1984 and 1995 and recovered between 1999 and 2008 (UNEP, 2009). The native fishery of the lake consisted of African catfish (*Clarias gariepinus* Burchell), lung fish (*Protopterus aethiopicus* Heckel) and haplochromines (*Haplochromis* spps). Three tilapia species: Nile tilapia (*Oreochromis niloticus* Linnaeus), Blue spotted tilapia (*O. leucostictus*Trewavas) and Red belly tilapia (*Tilapia zillii* Gervais) were introduced in 1956 to boost fish production (Okaranon, 1987). Following the introductions, fishery yield increased from about 1,000 tons annually in 1960 to a peak of 7,100 tons in 1967 but later dropped to 500 tons in 1982 (Okaranon, 1993). It increased to about 4,500 tons in 2,000 but again dropped to 1,200 tons by 2013. The changes in yield were attributed to over-exploitation because fishing boats increased from 250, the number that was required on the lake, to about 750 (Okaronon, 1993). However, current observations suggested a relationship between fluctuations in fish yield and climate variables especially rainfall (Natugonza et al. unpublished).

It is apparent that the communities around the lake are vulnerable to climate variability and change. There is therefore need for planned adaptation and mitigation measures to reduce the impacts (Badjeck et al. 2009). However, the development of planned adaptation and mitigation measures is limited by inadequate information. There is need to generate knowledge on demographic characteristics of the fishers, their livelihoods, and the impacts of climate variability and change on the livelihoods and available adaptation and mitigation measures to enable the communities become more resilient to the impacts of climate variability and change.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was carried out among fishing communities around Lake Wamala in Central Uganda (Figure 3-1), located in the Lake Victoria basin. The lake was chosen for this study because it had historically manifested changes in water levels, fish species composition and fish yield associated with changes in climate variables especially rainfall.

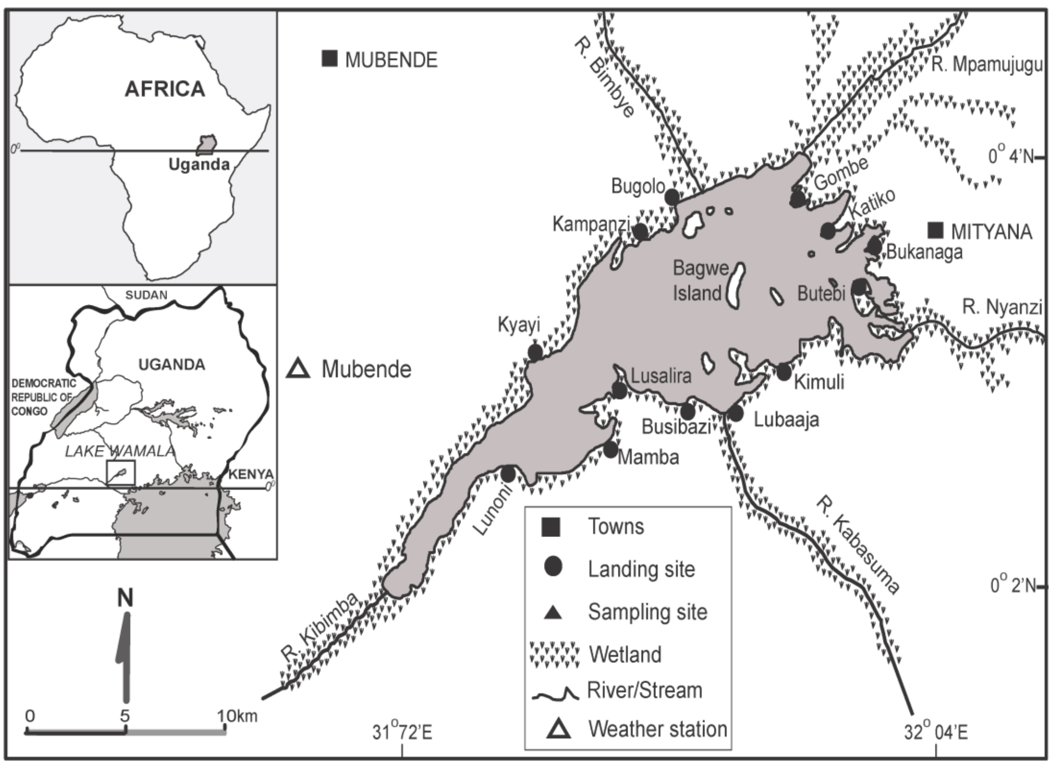

Figure 3-1. Location of Lake Wamala indicating landing sites (including the ones visited) and Mubende weather station (inset is location of Uganda within Africa.)

3.2 Research design

Primary and secondary data were used for the study. Primary data was collected using a semi structured questionnaire, Focus Group Discussions (FGDs) and key informant interviews in 2013 and 2014. The semi-structured questionnaire (Appendix 1) was administered to a total of 54 heads of fishing households selected through random sampling. The households were from five landing sites around the lake namely; Katiko, Butebi, Gombe, Lubaaja and Lusalira (Figure 3-1). The questionnaire covered fishers' perceptions of climate variability and change, demographic characteristics, livelihood activities, impacts of perceived climate variability and change on livelihoods, adaptation and mitigation measures, constraints to adaptation and mitigation and required interventions.

The secondary data included data on climate variables (mean maximum temperature, mean minimum temperatures and total rainfall) and fish catches. The data on the climate variables from 1970 to 2012 was obtained from Uganda National Meteorological Authority for Mubende weather station that is the nearest to the lake (Figure 3-1). Data on fish catches was obtained from the National Fisheries Resources Research Institute (NaFIRRI), Uganda and was available for years 1999, 2000, 2012 and 2013.

3.3 Field data collection

3.3.1 Perception of fishers to climate variability and change

Data on perceptions to climate variability and change was collected using the semi-structured questionnaire and included fishers' knowledge on whether climate was varying or changing and occurrence of climatic events within year and over years.

3.3.2 Demographic characteristics and livelihoods of fishers

Data on demographic characteristics and livelihoods was collected using the semi-structured questionnaire. The demographic characteristics were collected and used to determine their influence on adaptation. They included sex, age, household size, education level, membership to social groups, use of communications technology like radios and mobile phones, fishing experience, marital status, residence status and land ownership. Livelihood activities included information on only fishing related activities carried out by fishers, fish species targeted, gears used and what fishers perceived was current status of quantities of fish species.

A time budget analysis tool modified from Socio-Economic and Gender Analysis approach (FAO, 2001) was used to determine daily livelihood activities of an average man or woman and how they distribute time to the activities. Data was obtained using two FDGs that were organized at Katiko landing site (Figure 3-1), each for men and women of different age and socio-economic groups. Each group consisted of 10 members and age ranging from 27-50 years for men and 18-49 year for women. The objectives of the discussions were explained to the members and data was obtained using guide questions in Appendix 2

3.3.3 Perceived impacts of climate variability and change on the livelihoods, adaptation and mitigation measures, related constraints and required interventions

The impacts of perceived climate variability and change on the livelihoods included fishers perception of how climate events (floods and droughts) were associated with their livelihoods including target species, fish yield, physical assets like gears, boats and landing sites, lives, income from fishing and fish consumption. Adaptation measures included activities carried out by the fishers to respond to the perceived impacts of the perceived climatic events. Mitigation measures were activities that contributed to reduction in climate variability and change. Constraints to adaptation and mitigation were what the fishers thought were hindrances to adaptation and mitigation while interventions were what were required to enhance adaptation and mitigation. The data on the impacts, adaptation and mitigation measures, related constraints and required interventions was also collected using the semi-structured questionnaire.

A total of 15 fishers or former fishers (innovators) who improved their income by diversifying to non-fishery livelihood activities (innovations) as a form of adaptation, were identified in collaboration with the fishers and local leaders. Key informant interviews (Appendix 3) were used to determine their innovations as well as their benefits from which other fishers and lakeside communities could learn from to improve income and food security. A benefit analysis tool, modified from Socio-Economic and Gender Analysis approach (FAO, 2001) was used to determine benefits from the innovations for both men and women. Data was obtained from the two FDGs organized for men and women as in section 3.3.2 above.

3.4 Data analysis

Mann Kendall test was used to examine trends in the climate variables. Total rainfall, mean maximum and mean minimum temperature anomalies were determined to provide an impression of variations in climate variables. The anomalies were departures from the 1981-2010 mean, the most recent 30-year period for calculating climate anomalies (Fathauer, 2011). Annual average rainfall was determined for the years 1970 to 2012. Standardized precipitation Index (SPI) was used to provide an assessment of drought severity based on the probability of the observed total annual rainfall deviating from the 1981-2010 average. The years were classified according to McKee and colleagues (1993). The catch data was used to determine the contribution of each fish species to catches (species catch composition) and was presented graphically and compared to the fishers' current perception of the changes in quantities of fish species.

Descriptive statistics including frequencies and relative proportions were determined to summarize the data from the semi structured questionnaire on fishers' perceptions of climate variability and change, demographic characteristics, livelihood activities, impacts of perceived climate variability and change on livelihoods, adaptation and mitigation measures, constraints to adaptation and mitigation and required interventions. Where possible, these were presented as graphs and tables. Diversification to crop and livestock agriculture among the fishers was examined using diversification indicators (Kristjanson et al. 2011). The indicators were individually created for crops, livestock and their combination. Important observations from the FDGs and key informant interviews were identified and noted and compared and contrasted between men and women. The income that fishers or former fishers obtained from fishing were estimated for a year and compared to the estimated annual income from their innovations. Time budget analysis was used to examine the daily activities of men and women and how they distributed their time and presented in a table.

A logistic regression model was used to examine the extent to which demographic characteristics influenced diversification of the fishers to non-fishery livelihood activities using the characteristics as predictors. A dummy dependent variable (DV) which took the value of one if a household diversified and 0 if not was created. The model of the relationship between the variable and the predictors was as follows:

$$DV = \beta 0 + \beta 1a + \beta 2m + \beta 3h + \beta 4e + \beta 5ms + \beta 6u + \beta 7k + \beta 8fw + \beta 9fd + \beta 10f + \beta 11r + \mu$$

Where; DV is the probability of the fishers to diversify, β_0 is the intercept, β_1, β_2……………β_{11} are coefficients associated with age (a), marital status (m), household size (h), education (e), membership to social groups (ms), use of communications technology (u), knowledge of timing of seasons (k), weekly fishing days in wet season (fw), weekly fishing days in dry season (fd), fishing experience (f) and residence status (r) as the predictors and μ is error term. In addition to the coefficients, the model provides values for significance and odds ratios, presented as sig and Exp (B) respectively. The coefficients provided the relationship between the probability of diversification and the predictors and if it was zero then there was no relationship and if it was not zero, then the predictor variables played roles in predicting diversification. The significance values identified the predictors which significantly predicted diversification or not and the odds ratios showed changes in odds for diversification for each unit change in the predictors. A description of the predictors and how they were expected to influence diversification are briefly summarized in Appendix 4.

CHAPTER FOUR

4.0 RESULTS

4.1 Fishers' perceptions of climate variability and change

All fishers were aware of variation and change in climate. April and December were perceived as the wettest and June and July as the driest months (Figure 4-1). Most fishers (70.4 %) reported that timing of the wet and dry seasons had become less predictable. A higher proportion (61.1%) was aware of years when drought occurred compared to 57.4% who had knowledge of years when flood occurred. Most (92.6%) of those who were aware of drought years reported major droughts in 1994-95 while 87% of those who were aware of floods reported floods that occurred in 1997-98 and 2011-2012. Most fishers (68.5%) perceived that the frequency of drought occurrence had decreased while 48.1% perceived that frequency of floods occurrence had decreased (Figure 4-2).

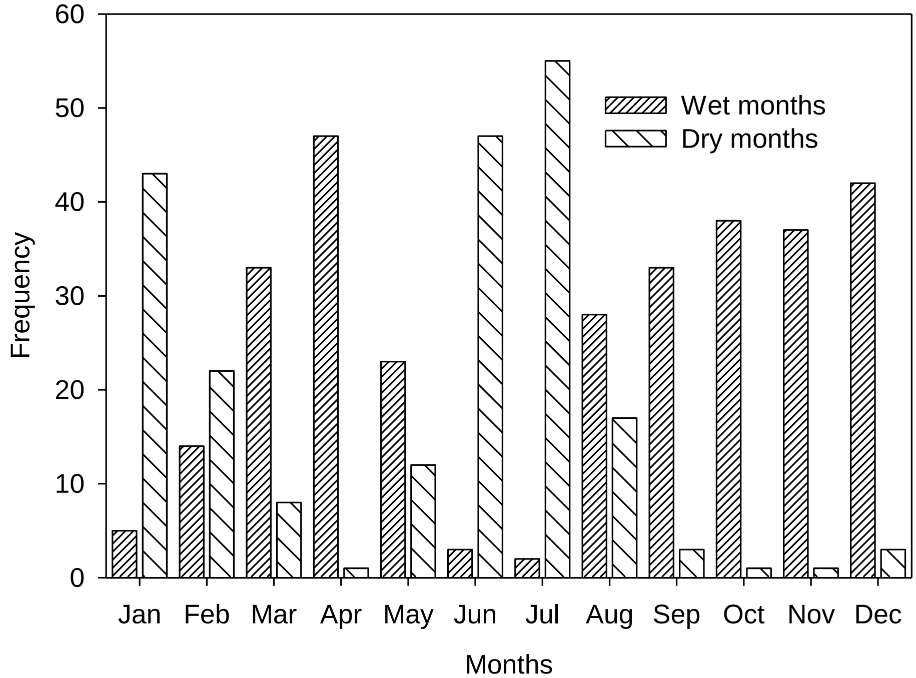

Figure 4-1 Frequency of months perceived as either dry or wet by fishers around Lake Wamala.

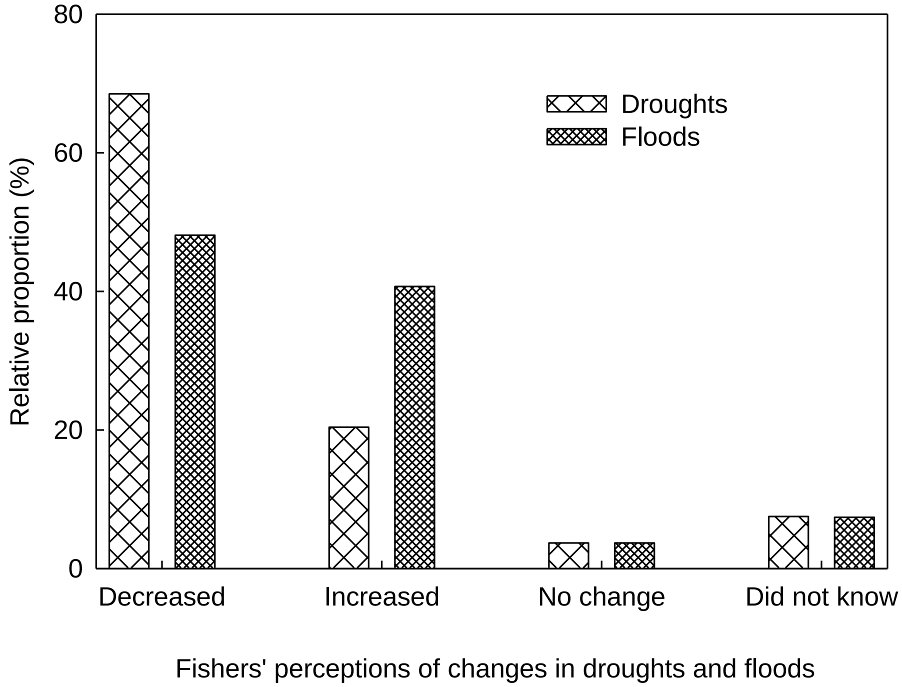

Figure 4-2. Relative proportions (%) of perceptions of fishers on changes in frequency of occurrence of perceived droughts and floods around Lake Wamala.

The perceptions of the majority of the fishers of decreased droughts were confirmed by the analyses of rainfall data that showed a significant increase in rainfall (Figure 4-3; P=0.0001) by 8.03mm annually since 1970, predominantly above average rainfall anomalies since 1988 and the SPI values which indicated more years tending to be wet since 1988 than before (Figure 4-4). However, there was high inter-annual rainfall variability, with the years after 1987 showing higher tendency of above average rainfall than before. The fishers' perception that the years 1997, 1998, 2011 and 2012 experienced floods, were supported by the observed above average rainfall for those years. The SPI also indicated that the years 1997 and 2012 were moderately wet while the years 2011 and 1998 received near normal rainfall. However, the perception of the majority of the fishers that the years 1994-95 experienced droughts, contradicted the rainfall analyses which indicated that they had above average rainfall and near normal SPI values. The fishers' perception of April and December as the wettest and June and July as the driest months was in line with the average rainfall which showed the months as wet and dry, respectively (Figure 4-5).

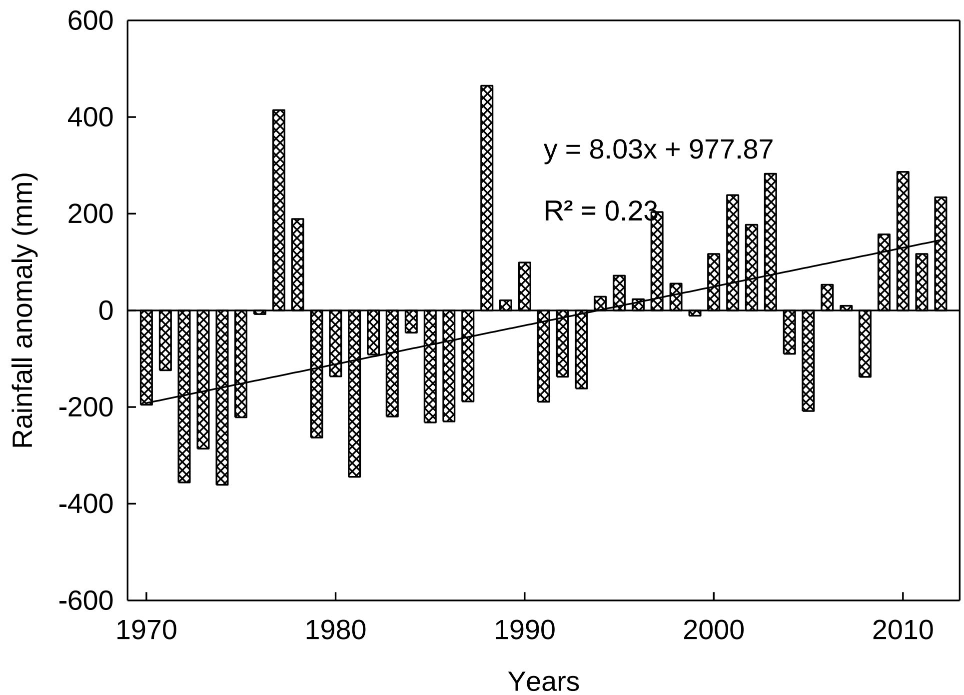

Figure 4-3. Time series annual rainfall anomalies (mm) for Mubende weather station near Lake Wamala calculated as departures from the 1981 to 2010 average (Source: Uganda National Meteorological Authority).

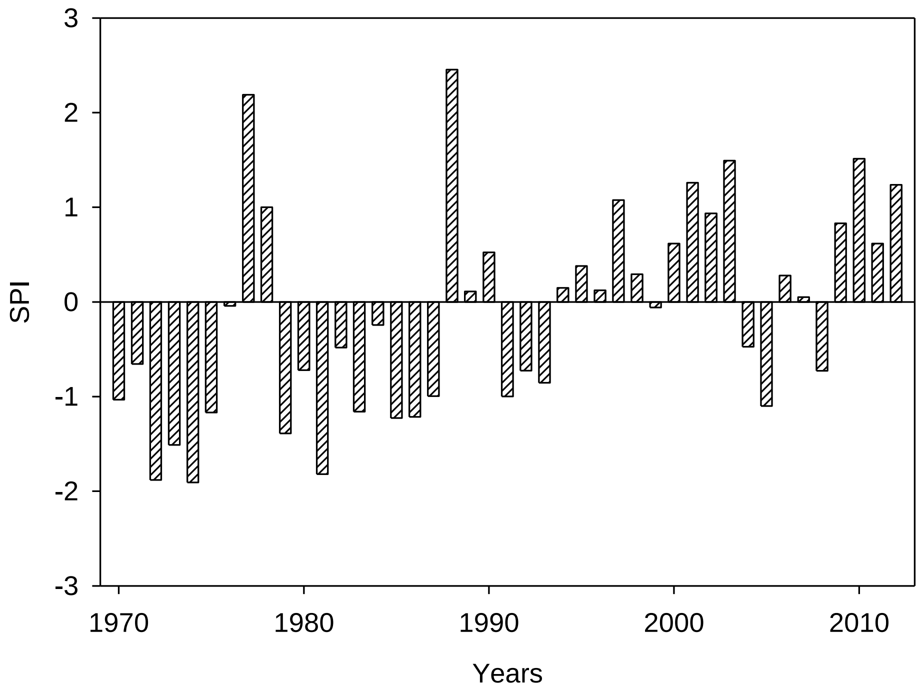

Figure 4-4. SPI series for Mubende weather station near Lake Wamala. The SPI provided an assessment of drought severity based on the probability of the observed total annual rainfall deviating from the 1981-2010 average (Source: Uganda National Meteorological Authority).

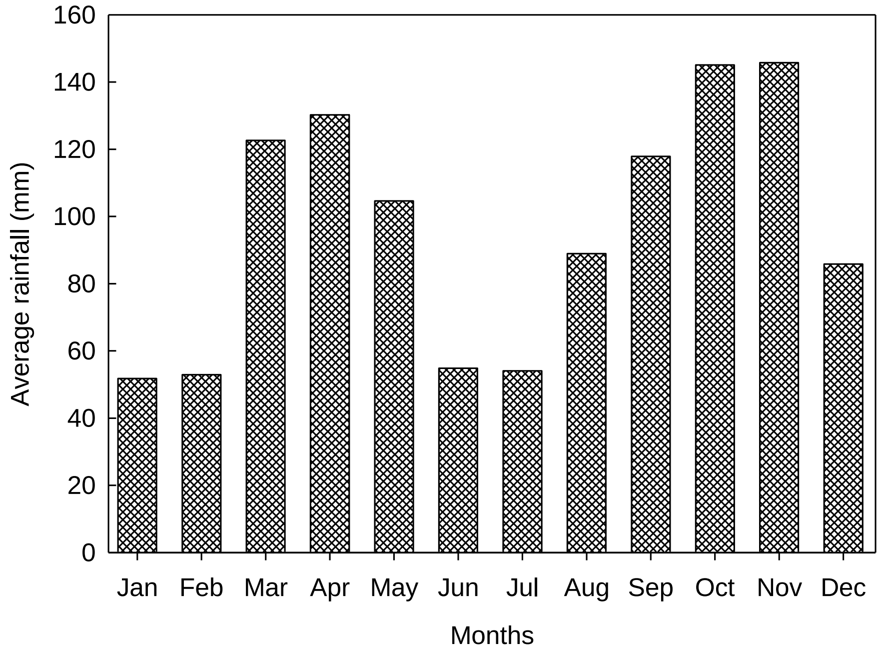

Figure 4-5. Monthly average rainfall (mm) for Mubende weather station near Lake Wamala, averaged for the years 1970-2012 (Source: Uganda national Meteorological Authority).

For temperature, there were highly positive anomalies from 1970 to 1976 for the maximum temperature (Figure 4-6a) and 2009 to 2012 for the minimum temperature (Figure 4-6b). The anomalies were erratic for the rest of the years. Since 1970, maximum temperature decreased by 0.03 ^{o}C annually while minimum temperature increased by 0.02 ^{o}C annually but the trends were non-significant.

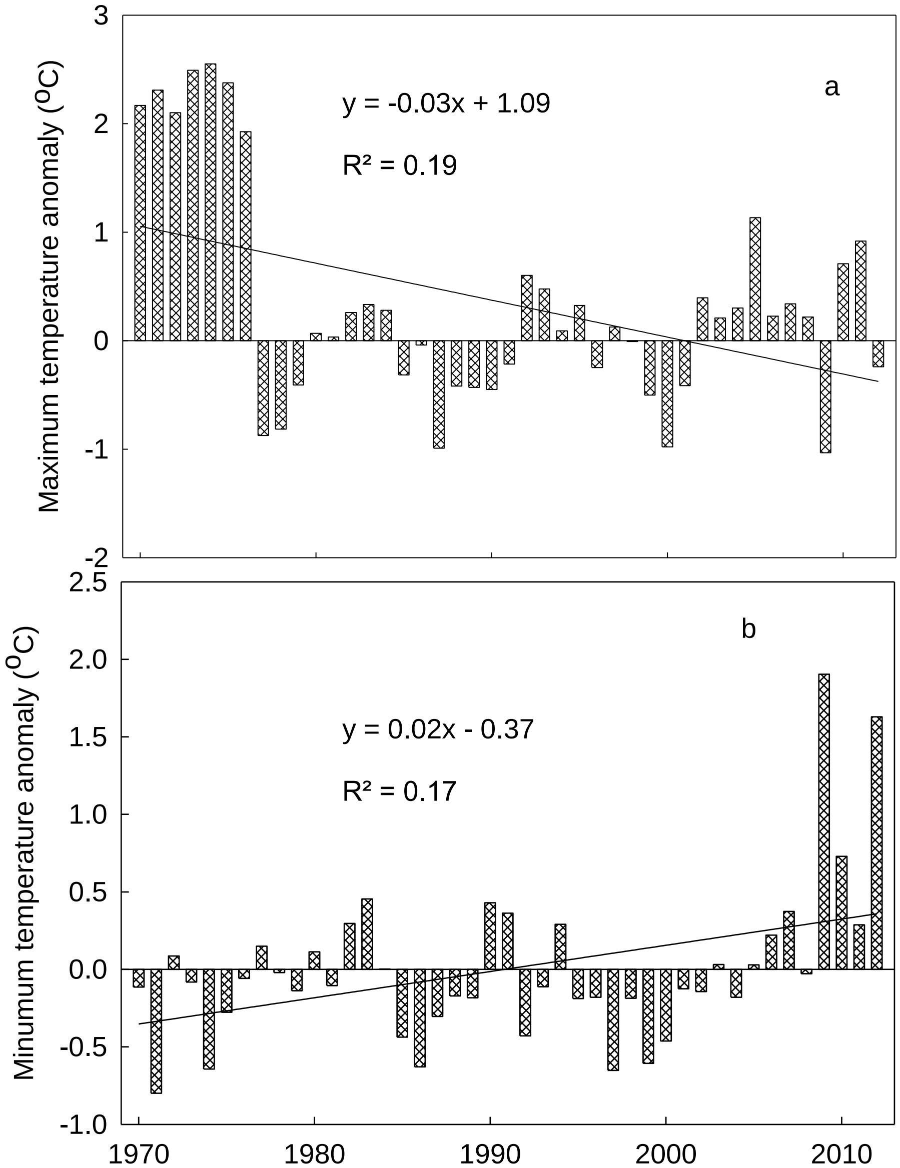

Figure 4-6. Time series annual mean maximum (a) and mean minimum (b) temperature anomalies (^{o}C) for Mubende weather station near Lake Wamala calculated as departures from the 1981 to 2010 average (Source: Uganda National Meteorological Authority).

4.2 Demographic characteristics

Virtually all fishers were men with 97% of them being economically active (age ranging from 20 to 60 years. The average fishing experience was 13 years. Only 40% of the fishers owned land (Table 4-1). The majority of the fishers (94.4%) had permanent shelters around the lake and overall, the fishers had lived around Lake Wamala for years ranging from 2-62 years (average 20 years). The average household size was five persons. Education level was however low with 14.8% having no formal education, 59.3% not having completed primary, 22.2% completed primary and only 3.7% with higher education (Table 4-1). There were social groups which included credit, fisheries, religious and agricultural whose role was mainly to provide credit facilities. However, 44.3% of the fishers were not members of any social groups (Table 4-1).

Table 4-1. Demographic characteristics of fishers around Lake Wamala.

Characteristics	Relative proportion/years/persons
Sex:	
Male	100%
Education:	
No formal education	14%
Incomplete primary	59.3%
Complete primary	22.2%
Secondary	3.7%
Marital status:	
Married	83.3%
Not married	16.7%
Household size (mean)	5
Land ownership	40%
Membership to social groups:	
Credit	27.9%
Fisheries	11.5%
Religious	9.8%
Agricultural	6.6%
No membership	44.3%
Use of communications technology	66.7%

4.3 Livelihoods

4.3.1 Fishery livelihood activities

Fishing was the main fishery livelihood of fishers during the wet and dry seasons (Figure 4-7). Other fishery activities included fish trading and renting fishing gear and boats. Fishing was on average conducted for five and three days per week during the wet and dry seasons respectively. The African catfish was the main target species (Figure 4-8) contributing 52% and 38% to the catches in the wet and dry seasons respectively. Most fishers (58.1%) perceived the catches of the African catfish to have increased and those of Nile tilapia to have decreased (Figure 4-9). A similar trend was observed from available data on catches where the contribution of the African catfish increased but that of the Nile tilapia decreased (Figure 4-10).

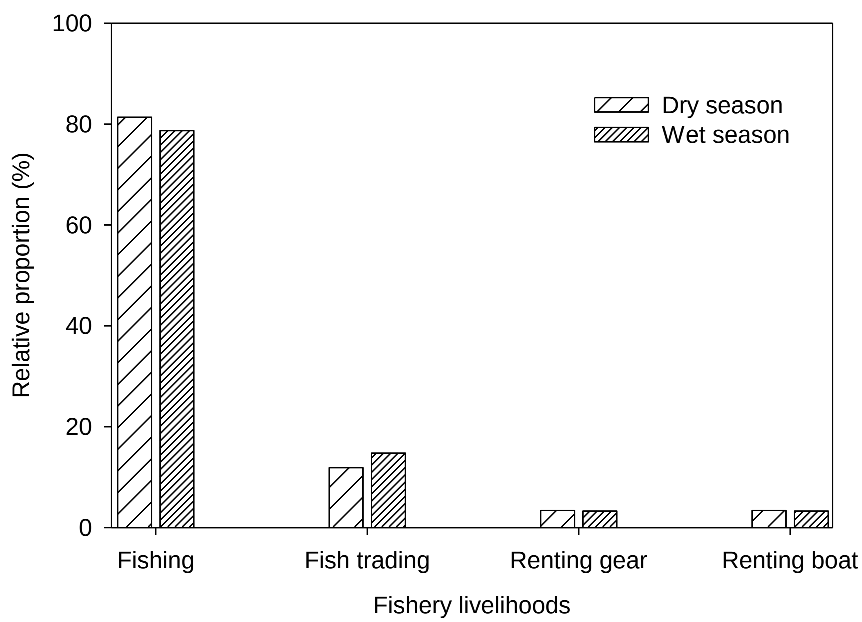

Figure 4-7. Relative proportions (%) of fishery livelihoods carried out by fishers around Lake Wamala during the dry and wet seasons.

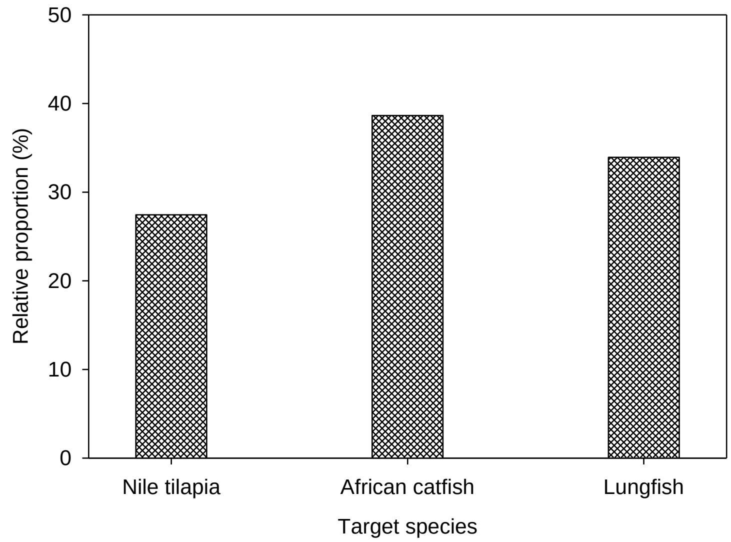

Figure 4-8. Relative proportion (%) of fish species targeted by fishers around lake Wamala.

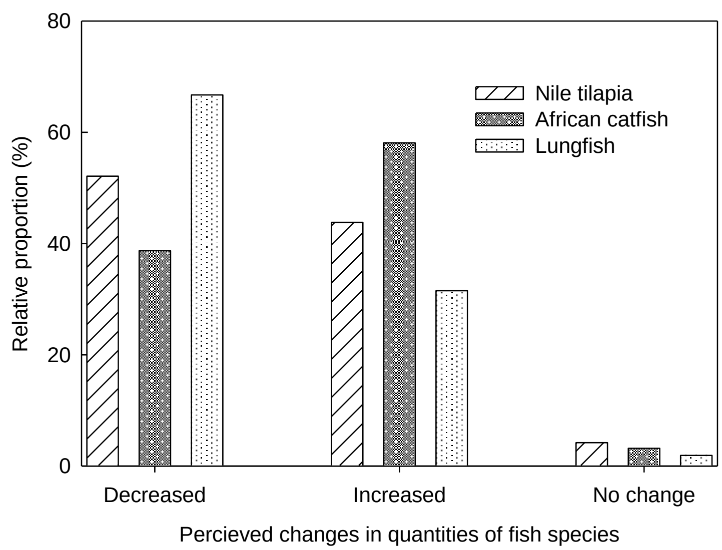

Figure 4-9. Fishers current perceptions of changes in quantities of target fish species around Lake Wamala.

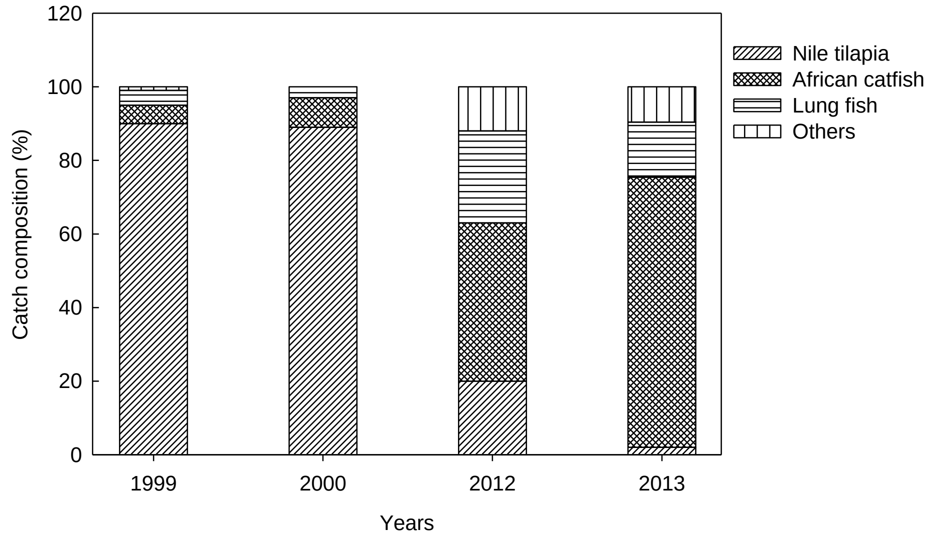

Figure 4-10 . Catch composition (%) of target species caught in Lake Wamala (Source: catch data from NaFIRRI archives).

The fishing gear consisted of gillnets (51.9%) and hooks (48.1%). The gillnet mesh size ranged from 38.1 to 127 mm with 101.6 mm being the most dominant (Table 4-2). Hook sizes ranged from numbers 4 to 14, but were dominated by number 7 (Table 4-3). Large proportions of the gill nets (93.2%) and hooks (44.4%) used on the lake were illegal.

Table 4-2. Relative proportions (%) of different mesh sizes of gill nets used by fishers around Lake Wamala (*i* indicates illegal gillnet mesh size).

Gillnet mesh size (mm)	Relative proportion (%)
38.1[i]	3.5
88.9[i]	3.5
101.6[i]	86.2
114.3	3.5
127	3.5

Table 4-3. Relative proportions (%) of different hooks numbers used by fishers around Lake Wamala (*i* indicates illegal hook number).

Number	Relative proportion (%)
4	9.4
6	3.1
7	34.4
8	12.5
9	6.3
10[i]	31.3
14[i]	3.1

4.3.2 Daily activities of men and women and time budget for the daily activities

During the FGDs, men reported their main activities as fishing, crop and livestock agriculture, brick laying, trading in merchandise and produce, informal employment such as providing labor for other people and offering transport using motorcycles (locally known as *bodaboda*). Fishing was the main contributor to household basic needs and income from fishing provided credit that was invested in crop and livestock agriculture. The men reported that both men and women were responsible for agricultural activities but women were more involved in growing food crops and men in cultivation of commercial crops.

The women reported their main activities as crop and livestock agriculture, running small restaurants, bars and retail shops, with very few women reported to be involved in fishing. They engaged in additional activities like making crafts from which they generated additional income. The women confirmed that they controlled agricultural activities that provided food for the family, while income generating activities were controlled by men who marketed the agricultural products and only gave women some of the money at their discretion.

Overall, men and women spent time on productive activities during wet and dry seasons like fishing, working in farms, caring for livestock, making crafts but women were involved in additional domestic activities like caring for children, preparing food, collecting fodder and water and cleaning house (Table 4-4). Unlike men who carried out most of their activities sequentially, women's activities were mostly simultaneous. The men spent most of their time on fishing in both wet and dry seasons but spent proportionately more time handling fish catch in the dry season while more time was spent working in the farms during the wet season. The women spent proportionately more time in the farms in the wet season and did not work in the farms in the dry season. Although the women carried out productive activities like feeding livestock and making crafts during the dry season, more time was spent on other household chores like caring for children and preparing food (Table 4-4). Resting for both men and women was simultaneous with other activities in both seasons. The resting time was longer in the dry season than in the wet season and women undertook more activities simultaneously with resting in both seasons than men, indicating that they rested for less time compared to the men (Table 4-4).

Table 4-4. Daily livelihoods and time budget (6.00 hours-24.00 hours) for men (diagonal hatches) and women (horizontal hatches) during wet and dry seasons around Lake Wamala.

								Hour						
	6	7	8	9	10	11	12	13	14	15	16	17	18-22	23-5
Wet season:														
Handling fish catch														
Prepare breakfast/care for children														
Working in garden														
Working in garden														
Resting/care for livestock														
Prepare food/care for livestock/rest/craft														
Work in the gardens/prepare fishing gear														
Work in gardens/look for food														
Fishing/sleep														
Care for livestock/prepare food/ bath children														
Sleep														
Dry season														
Handling fish catch														
Clean house/prepare breakfast/care for children/feed livestock														
Work in garden														
Resting/care for livestock/preparing fish gear														
Prepare food/ wash clothes/crafts/rest														
Crafts/resting														
Look for food														
Care for livestock/prepare food/ bath children														
Fishing /sleep														
Sleep														

4.4 Association between perceived floods and droughts and livelihoods

Droughts were mainly associated with reduced fish catches and sizes, damaged boats and loss of lives while floods were mainly associated with increased fish size, loss of gear, increased fish catches, damaged gear and landing sites (Table 4-5). Reduced fishing days, number of traders and fishing effort were only associated with floods. The African catfish was reported to dominate catches during floods (71.2%) while the Nile tilapia (40%) dominated the catches during droughts (Figure 4-11). A higher proportion of fishers (52.0%) reported decreased income from fishing during floods compared to droughts (Fig. 4-12a & b) and a higher proportion (41.2%) reported increased income during droughts compared to floods (Figure 4-12a & b). Almost equal proportions of fishers either did not know or respond to how their income was affected by floods and droughts. A higher proportion of fishers (50.0%) reported increased fish consumption during floods compared to droughts (Figure 4-12c & d) and a higher proportion (42.0%) reported decreased consumption during droughts compared to floods (Figure 4-12c & d). About 12.0% and 14.0% respectively reported that floods and droughts had no effect on consumption but higher proportions did not know or did not respond on how consumption was affected by droughts compared to floods.

Table 4-5. Relative proportions (%) of different ways perceived floods and droughts around Lake Wamala were associated with livelihoods by fishers.

Impact	Relative proportion (%)	
	Floods	Droughts
Reduced fish catches	5.8	23.2
Reduced fish size	0.9	12.0
Damaged to boats	4.9	11.3
Damaged landing sites	11.7	4.9
Loss of lives	11.2	13.4
Loss of gear	13.9	9.9
Reduced fishing days	8.1	-
Damage to gear	13.0	9.9
Reduced number of traders	0.5	-
Increased fish catches	13.0	6.3
Increased fish size	16.6	9.2
Reduced effort	0.5	-

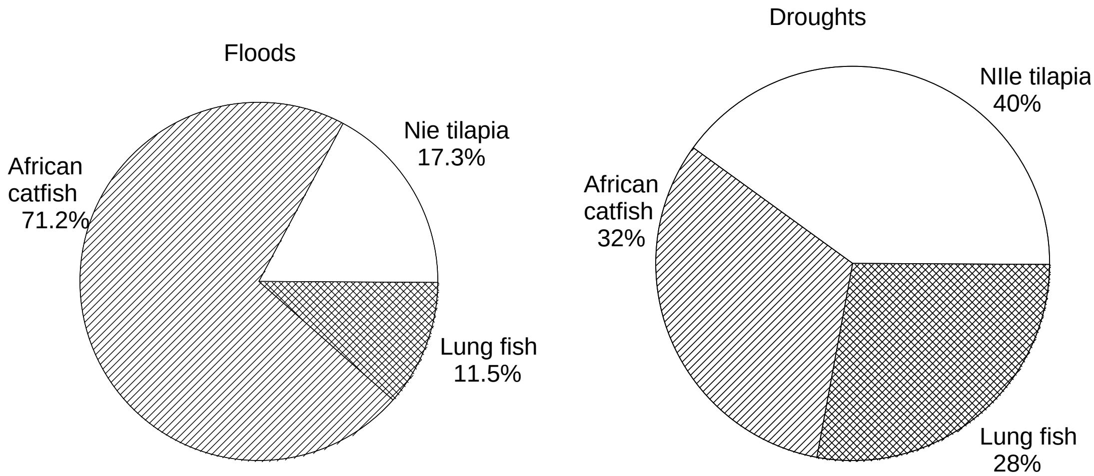

Figure 4-11. Relative dominance (%) of targeted fish species during perceived flood and drought periods on Lake Wamala.

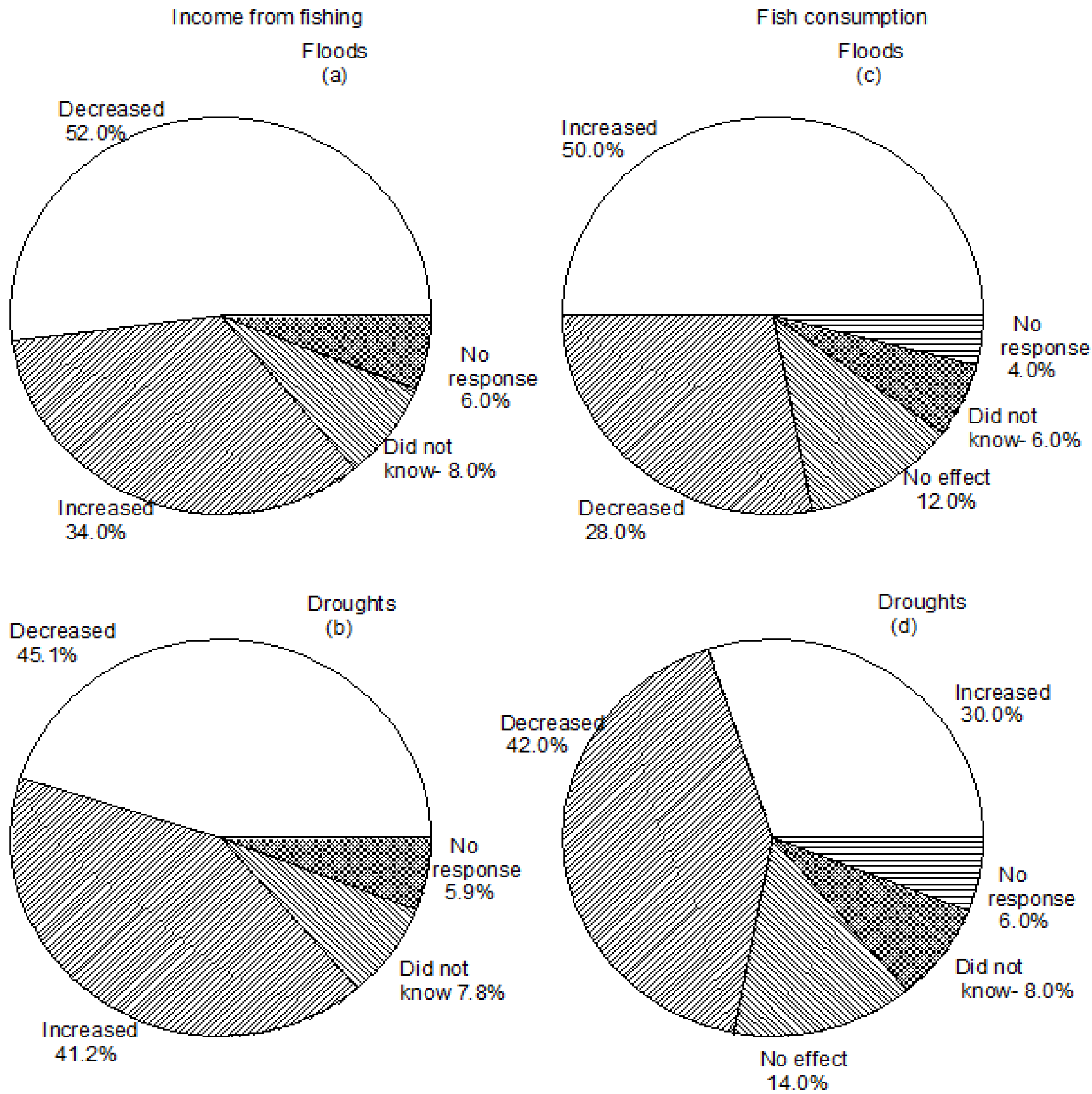

Figure 4-12. Relative proportions (%) of what fishers perceived as influences of perceived floods and droughts on income from fishing and fish consumption around Lake Wamala.

4.5 Adaptation measures and innovations

4.5.1 Adaptation measures

The adaptation measures of fishers to the perceived floods and droughts in order of importance included diversification to non-fishery activities, increasing time on fishing grounds, changing fishing grounds and target species, using more gear, increasing or decreasing fishing days and time on fishing grounds, changing landing site and exiting fishing (Table 4-6).

Table 4-6. Relative proportion (%) of adaptation strategies of fishers to perceived floods and droughts around Lake Wamala.

Adaptation measures	Relative proportions (%)
Diversification to non-fishery activities	20.9
Increased time on fishing grounds	16.8
Changed fishing grounds	15.8
Changed target species	13.6
Changed fishing gear	9.4
Used more gear	7.6
Decreased fishing days	7.0
Increased fishing days	4.7
Decreased time on fishing grounds	2.o
Changed landing sites	1.6
Exited the fishery	0.6

The non-fishery activities that the fishers reverted to were mainly crop and livestock agriculture (Figure 4-13). The most important crops were sweet potatoes, cassava, maize and beans (Figure 4-14) while the most important livestock were pigs and chicken (Figure 4-15).

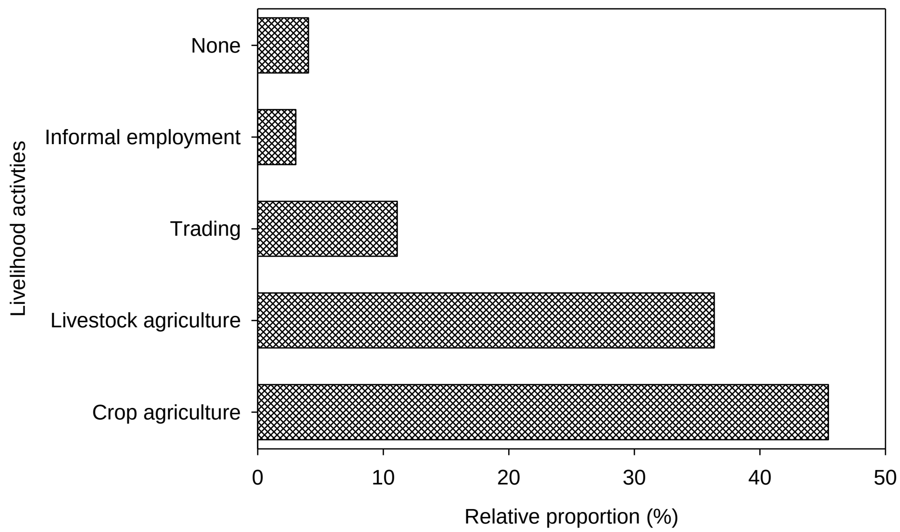

Figure 4-13. Relative proportion (%) of the non-fishery livelihood activities diversified to by fishers around Lake Wamala.

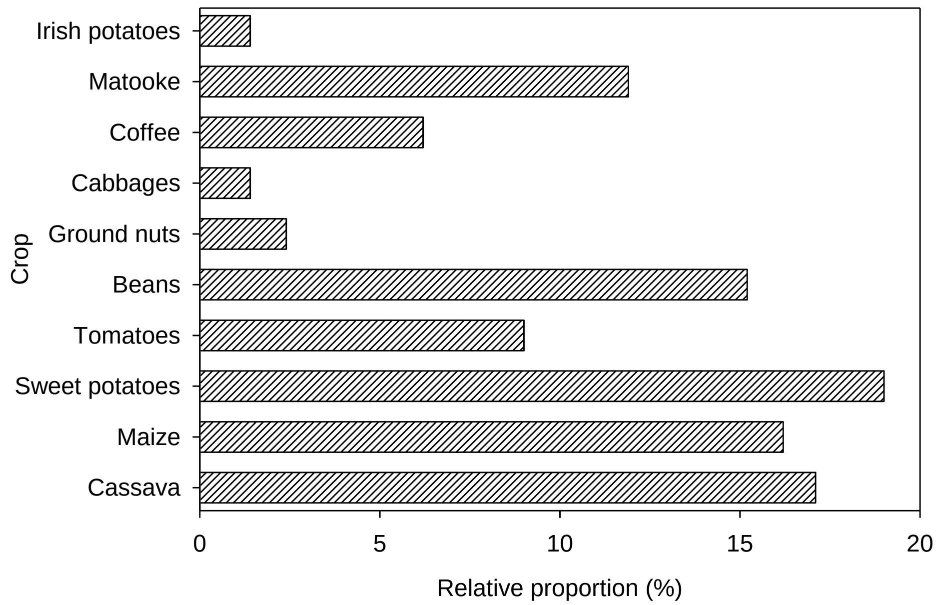

Figure 4-14. Relative proportions (%) of different crops grown by fishers around Lake Wamala.

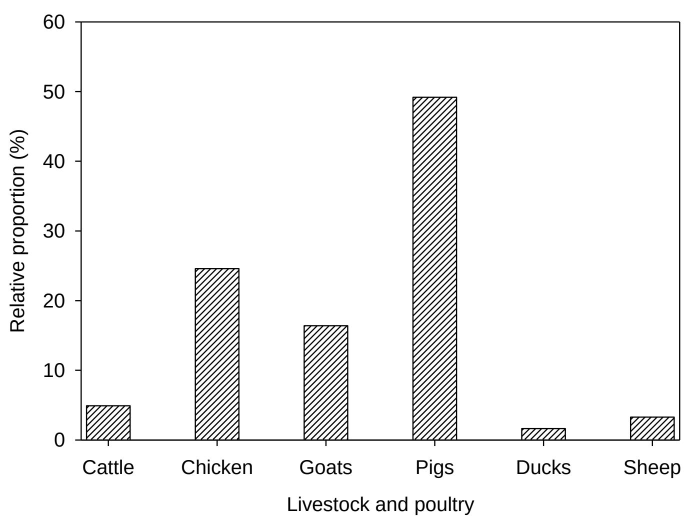

Figure 14-15. Relative proportions (%) of livestock and poultry reared by fishers around Lake Wamala.

The diversification indicators (Table 4-7) showed most of the fishers with low (40.7%) and intermediate diversification (38.9%) to crops and low diversification (63.0%) to livestock. Overall, most of the fishers had intermediate (38.9%) and low (29.6%) diversification (Table 4-7). Crop and livestock agriculture were also affected by climate variability and change. The crop related adaptations, in order of importance included changing planting dates, cultivating early maturing crops, crop diversification and irrigation (Table 4-8). Livestock related adaptations included grazing near lake shores, collecting fodder, fodder production and collecting water for livestock, reducing the number of animals reared, practicing zero grazing, and buying feed supplements (Table 4-9).

Table 4-7. Diversification indicators of fishers around Lake Wamala.

Production diversification indicator	Percentage of fisher household		
	Crop	Livestock	Overall
No diversification	18.5	35.2	14.8
Low production diversification	40.7	63.0	29.6
Intermediate production diversification	38.9	1.9	38.9
High production diversification	1.9	-	16.7

Table 4-8. Relative proportions (%) of crop agriculture related adaptations to perceived floods and droughts by fishers around Lake Wamala.

Adaptation strategies	Relative proportion (%)
Changed planting dates	38.3
Cultivated early maturing crops	22.4
Diversify to other crops	12.0
Carried out irrigation	11.0
Farmed near shore	9.4
Used drought resistant crops	7.0

Table 4-9. Relative proportions (%) of livestock agriculture related adaptations to perceived floods and droughts by fishers around Lake Wamala.

Adaptation strategies	Relative proportion (%)
Grazed near the shore	23.8
Collected fodder	19.0
Collected water for livestock	14.3
Produced fodder	14.3
Reduced number reared	9.5
Carried out zero grazing	9.5
Bought feed supplements	9.5

4.5.2 Innovations and their benefits to both men and women

Innovators were fishers who diversified their livelihoods to a variety of non-fishery activities or former fishers who carried out other activities (see Plates 1-4). These were involved in growing high value crops like tomatoes, cabbages, pepper, oranges, pineapples and bitter berries which were sometimes inter-planted with other crops like bananas and operating business like dealing in agricultural products. Some of the crops like tomatoes and oranges were grown during drought under irrigation to target higher prices during periods of scarcity. The cattle, goats, pigs and poultry provided manure for crops. The estimated annual income from on farm innovations was US$ 3,400 compared to US$ 1,400 from fishing. This increase in income acted as an incentive to the extent that some fishers had to quit fishing.

Men reported that the innovations were for income, employment, food security and meeting household needs which had increased mainly with diversification to crop and livestock agriculture. Other benefits included manure and feed for livestock and mulching materials. They reported that both men and women controlled the benefits but men were responsible on how the income was spent. Women reported similar benefits from the innovations as men. The women were responsible for feeding livestock, applying manure and mulching farms under the guidance of men. However, women reported that men used some of the income for their activities like drinking alcohol with limited accountability to the women.

4.5.3 The influence of demographic characteristics on diversification

The R^2 value (0.55) showed that there was a moderately strong relationship between the predictors and the probability of diversification to non-fishery activities by the fishers around

Lake Wamala (Table 4-10). The positive coefficient values (B) showed that diversification was enhanced by age, membership to social groups, use of communications technology, weekly fishing days in wet season and fishing experience, with only use of communications technology and the fishing days being significant. The rest of the variables exhibited none significant negative relationships, indicating that they limited diversification. The odds ratios (Exp (B)) showed that use of communications technology, membership to social groups and weekly fishing days in the wet season had the highest chances of enhancing diversification and a unit increase in each could increase diversification by 43.43, 5.70 and 5.35 times respectively. A unit increase in household size had the highest chances (0.88) of decreasing diversification.

Table 4-10. Logistic regression coefficients of the demographic characteristics that influence the capacity of fishers around Lake Wamala to diversify to non-fishery activities.

Variables/Predictors	B	S.E.	Wald	Sig.	Exp (B)
Age	0.011	.107	0.011	0.917	1.01
Marital status	-0.505	1.817	0.077	0.781	0.60
House hold size	-0.131	.192	0.464	0.496	0.88
Education	-1.509	1.764	0.732	0.392	0.22
Membership to social groups	1.740	1.458	1.424	0.233	5.70
Knowledge of timing of seasons	-4.347	2.374	3.353	0.067	0.01
Use of communications technology	3.771	1.842	4.192	0.041	43.43
Weekly fishing days in wet season	1.676	.790	4.501	0.034	5.35
Weekly fishing days in dry season	-0.887	.518	2.935	0.087	0.41
Fishing experience	0.089	.150	0.350	0.554	1.09
Residence status	-22.996	1.89	0.000	0.999	0.00
Constant	26.459	1.89×10^4	0.000	0.999	3.10×10^{11}
Nagelkerke R Square				0.55	

4.6 Mitigation measures

Majority of the fishers (83.3%) practiced mitigation measures. These were in order of their importance: protecting wetlands (50.7%), planting trees (42%) and mulching gardens (7.2%).

4.7 Constraints to adaptation and mitigation

The constraints to adaptation and mitigation were limited credit facilities, awareness, land, appropriate planting materials, inadequate law enforcement, lack of affordable irrigation facilities and high dependence on only fishing **(**Table 4-11).

Table 4-11. Relative proportions (%) of constraints to adaptation and mitigation reported by fishers around Lake Wamala.

Constraints	Relative proportion (%)
Limited credit facilities	26.4
Limited awareness	21.9
Limited land	21.4
Lack of appropriate planting materials	11.7
Inadequate enforcement of laws and regulations	10.7
Lack of affordable irrigation pumps	5.1
Dependence on one economic activity	2.8

4.8 Required interventions

The interventions required to overcome the constraints included: provision of low interest credit facilities, increasing awareness, and provision of affordable irrigation pumps and appropriate planting materials and enforcement of existing laws and regulations (Table 4-12).

Table 4-12. Relative proportions (%) of interventions required to reduce the constraints to adaptation and mitigation reported by fishers around Lake Wamala.

Interventions	Relative proportions (%)
Provide low interest credit facilities	28.6
Increase awareness	26.8
Provide irrigation pumps	16.1
Provide appropriate planting materials	16.1
Improve enforcement of laws and regulations	12.5

CHAPTER FIVE

5.0 DISCUSSION

5.1 Perception of fishers to climate variability and change

Fishers were aware of variations and changes in climate and its manifestations through perceived climatic events such as less predictable seasons, floods and droughts. Some of their perceptions were related to recorded rainfall around the lake with, for example, the years perceived to have experienced floods having above average rainfall and positive SPI values. This awareness is increasing globally (Aphunu & Nwabeze, 2012) and will contribute to stimulation of responses through adaptation and mitigation measures (Downing, 1996). This awareness is also an important starting point to realize that there is a problem that needs to be addressed. However, perception to local climate is subjective in some cases (Howe & Leiserowitz, 2013), and could explain some of the variations in the perceptions among the fishers and the contradiction between some of the fishers' perceptions and climate data. The observed high inter-annual variability in rainfall and increased mean minimum temperature were comparable to climate variability and change assessments for Uganda (USAID, 2013). However, USAID (2013) reported a none clear trend in rainfall and increased mean maximum temperature over Uganda, which contradict the observed increase in rainfall and decrease in mean maximum temperature over Lake Wamala. This suggests temperature and rainfall patterns over Uganda may not be homogeneous. Although mean maximum temperature decreased, temperature around Lake Wamala is hotter since mean minimum temperature increased. This has been associated with increased evaporation rates that offset gains by the increased rainfall resulting into negative water balance for the lake (Natugonza et al. unpublished).

5.2 Fishery Livelihoods

The fishing activities carried out by the fishers around Lake Wamala almost had equal proportions during dry and wet seasons, indicating equal importance of each of the activities to the fishers in both seasons. The perceptions of majority of the fishers; that the African catfish was the main target species that contributed most to catches and that its catches had increased were in line with the data on fish catches which indicated that the African catfish comprised about 73.4% of all catches by 2013. The African catfish fishery can be considered an "emerging fishery" as the Nile tilapia dominated catches by 1999, when it comprised 90%. Since then, the contribution of the Nile tilapia to the catch has been decreasing and was about 2% by 2013, compared to 73.4%% contributed by the African catfish. The decline of Nile tilapia could be linked to the reduced lake levels Lake Wamala has experienced and sustained since 1980s (UNEP, 2009), which probably created unfavorable conditions by reducing volume and area of open water habitat probably causing overcrowding, competition for food and breeding and nursery areas and exposure to high fishing pressure (Lowe-McConnell, 1958). Conversely, the capacity of the African catfish to utilize marginal wetlands with less water and low oxygen levels (Van der Waal, 1998) may be enhancing its survival under the conditions of reduced and sustained water levels. These changes in fish composition may be influencing the types and sizes of gears. Okaronon (1987) reported 88.9mm as the lowest mesh size of gillnets on the lake but this dropped to 38.1mm observed in this study and no hooks were previously known to be used on the lake. The small mesh size gillnets were adopted most likely to exploit the remaining Nile tilapia while the hooks appear to have emerged with the increase in composition of the African catfish in the catches. The upsurge of illegal gears may be a response of fishers to increase catches as overall fish yield from the lake decreased (NaFIRRI unpublished report).

The time allocation budget for the men and women (Table 4-4) illustrated how they distribute and use their time among different activities. The time budget was in line with reports that men mostly work out of the home while women work in and out of the home (ILO, 1998; Levine et al., 2001; ITCILO, 2013). This suggests that both men and women have time constraints-which are expected to increase with the demands from other activities as a result of adaptation to the influence of climate variability and change. Therefore, enhancing adaptation around Lake Wamala will require mitigation of the time constraints, by for example, promoting interventions like low cost water harvesting and wood fuel saving technologies. These would increase availability of water and fuel in homes, reducing the time women spent on securing their households for water and fuel, thus creating more time for other activities. The time budget also is in line with reports that women are stewards of household food, water and fuel security (FAO, 2011) and therefore possess expertise and are appropriately positioned to enhance adaptation interventions around the lake.

5.3 Association of perceived floods and droughts with livelihoods

Livelihoods of fishers are affected when climatic events affect their livelihood components, activities and outcomes (Balgis et al. 2005; Allison et al. 2005). The different ways the perceived flood and drought events influenced the livelihoods of fishers on Lake Wamala (Table 4-5) have been reported elsewhere among fishing communities in relation to climate variability and change. These events are associated with loss of lives, damage to boats, fishing gear, landing sites and other community infrastructure as well as disrupting fishing activities (Jallow et al. 1999; Westlund et al. 2007). Changes in dominance and composition of fishes also occur as a result of these events (Cheung et al. 2009) and could explain the reported differences in species dominance, fish catches and fish size in the lake associated with the events. The lower income during the perceived floods vis-à-vis the higher catches associated with them could be explained by the higher catches that result into higher fish supply and low demand, thus preventing fishers from realizing increased income (Broad et al. 1999). Conversely, low fish supply resulting from reduced catches during perceived droughts increases demand and results in higher prices enabling fishers to fetch higher income. The higher catches associated with the perceived floods avail more fish for consumption compared to droughts, corresponding to the higher consumption and vice-versa. In addition, practices carried out by fishers on Lake Wamala like increasing time on fishing grounds as adaptation measures, increase fishing costs thus affecting income and consumption (Mahon, 2002; Perry et al. 2009).

5.4 Adaptation, innovations and mitigation measures

The adaptation measures of the fishers observed on Lake Wamala are similar to those that have been reported among other fishing communities (Allison et al. 2007; Turner et al. 2007; Brugere et al. 2008). Diversification to non-fishery activities could be the most beneficial as it successfully contributes to improved income, food security and employment for fisher communities (Brugere et al. 2008). Fisher households with diversified-farming activities are reported to have belter wellbeing than those without (Bene, 2009). Such values were also demonstrated in this study for the innovators who diversified to crop and livestock agriculture realized increased income beyond what was earned from fishing leading to some of them quitting fishing activities. The fishers' adaptation measures of decreasing fishing days and time on fishing grounds and exiting the fishery could also improve income and food security if time created is diverted to productive non-fishery activities including agriculture. However, these measures especially exiting the fishery are less practiced among the fishers indicating that few fishers are willing to depend exclusively on non-fishery activities. This could partly be due to open access nature of fishing activities, limited land and alternative employment that make fishers stick to fishing activities (Lwenya et al. 2009) or limited awareness of the benefits of non-fishery activities to income and food security. This emphasizes the need for increased awareness among fishers and providing opportunities to enhance diversification to non-fishery activities. However, the diversification indicators (Table 4-7) showed low diversification to crops and livestock and overall intermediate diversification, requiring more efforts to promote diversification even among fishers who have already involved in non-fishery activities. This could be easier on Lake Wamala as fishers already acquired some crops and livestock but need to be encouraged to diversify to the high value crops like oranges and pineapples which the innovators used. On the lake, this would benefit from the innovators as role models and their innovations as “field schools” from which others can learn. The rest of the adaptation measures of the fishers like increasing time on fishing grounds and fishing days and changes in types and number of fishing gears are strenuous activities which may not necessarily be beneficial especially under declining fish yield and could perpetuate unsustainable fishing practices.

Relating to the crop and livestock related adaption measures, measures like changing planting dates, cultivating early maturing crops, irrigation and zero grazing innovative ways to respond to stressors including climate variability and change (Kristjanson et al. 2012) and should be supported. However, measures such as farming and grazing near the lake shore indicate that diversification to crop and livestock agriculture could encourage inappropriate land use and land use change involving encroachment on critical habitats like wetlands, deforestation, and use of fertilizers, weed and pesticides. If not properly managed, these could exert more stress on fish habitat (Alabaster, 1981; Allison et al. 2007) undermining the benefits from diversification as an adaptation measure.

It is also important to note the differences among men and women on control of benefits from the innovations. For example, the reported control of women over mulching materials and manure could be tapped into in enhancing adaptation through climate-smart agriculture practices. Men could also contribute to adaptation by reducing or stopping the reported diversion of income to non-productive activities like drinking alcohol but instead use the income to provide support for more productive activities and also allow equal control over income.

The mitigation measures by the fishers have been demonstrated to contribute to reduction of greenhouse gases by acting as carbon sinks (Huang et al. 2014). These should be promoted to contribute to global climate change mitigation targets.

5.5 The influence of demographic characteristics on diversification to non-fishery livelihoods

Demographic characteristics are important for shaping communities' response to climate variability and change through influencing adaptation measures (Scheraga & Grambsch, 1998). This study demonstrated that the demographic characteristics of fishers around Lake Wamala could either enhance or limit their capacity to adapt by diversifying to non-fishery livelihoods. Age, membership to social groups, use of communications technology and fishing experience, enhanced adaptation as had been predicted (Appendix 4). Weekly fishing days in wet season had been predicted to limit diversification but instead appeared to be enhancing it. This could be possible as fishing provides capital for on-farm investments (Njaya et al. 2011) and more fishing days could enhance diversification when fishers on Lake Wamala access more credit from fishing and divert it to support non-farm activities. Marital status, household size, education, knowledge of timing of seasons and residence status were indicated to limit diversification contradicting what had been predicted (Appendix 4) and are commonly known to increase adaption (Maddison, 2006). The role of these should be investigated and elaborated further in future studies.

In line with the observation on demographic characteristics of the fishers around the lake (Table 4-1), most fishers were within the economically active age range (20-60 years) and this can enhance adaptation measures, including fishery based ones as it could facilitate undertaking of strenuous tasks associated with fishing to improve fish catch (Olaoye, 2010). The permanent shelters and demonstrated ownership of land among the fishers could enhance long-term and land based adaptation and mitigations measures. Social groups should be encouraged. The low education levels among the fishers and large household size were typical of fisher communities (Olago, 2007).

5.6 Constraints to adaptation and mitigation measures and required interventions

The knowledge by the fishers of constraints to adaptation and mitigation measures and the possible interventions to reduce them was remarkable. The constraints result from limited physical infrastructure and access to basic services like credit that characterize most fisher communities (Olago et al. 2007; Iwasaki et al. 2009; MRAG, 2011). For successful adaptation and mitigation, these constraints should be addressed (Bryan et al. 2009) with several interventions although priority should be given to what fishers reported. Interventions like increasing awareness will enable communities to recognize the necessity to adapt or mitigate, acquire knowledge about available options, the capacity to assess them and implement the most suitable ones (Fankhauser & Tol, 1997). Other interventions such as training increase skills that can assist fishers to adapt (Shaffril et al. 2011) and should be promoted. There is also need to improve physical infrastructure and access to basic services like health and credit whose limitation exacerbates the constraints in most fisher communities.

5.7 Implications for policy, management and planned adaptation

In this study, some adaption measures of the fishers appeared more negative and some may not be beneficial. More positive and habitat friendly adaptations are needed with efforts geared towards encouraging positive adaptations especially diversification to non-fishery activities and discouraging negative ones. However, diversification is not always beneficial for all fishers and policy should provide diversification opportunities as well as addressing the constraints for adaptation with priority given to fishers own interventions like raising awareness and providing credit. As diversification resulted into some fishers quitting fishing, diversification can reduce fishing effort and should be used as part of other fisheries management tools. Management efforts are needed to control the illegal gears and develop a lake specific management plan for the emerging African catfish fishery. Uganda's Fish Act provides for minimum mesh sizes and nine as a minimum hook size for all lakes in the country and if implemented, could reduce the use of the illegal fishing gears. The Act also provides minimum length of fish to be harvested (25 cm total length for Nile tilapia) but no size limit exists for the African catfish and could benefit from policy changes to address the size limits. There exists a provision to protect 200m of shorelines as buffer zones on all lakes in Uganda and this should be implemented to manage the negative consequences resulting from diversification to crop and livestock agriculture like encroachment on wetlands, grazing and cultivating up to the shores. There are also other policy provisions targeting protection of wetlands and promoting tree planting that can be beneficial if implemented. Basing on the knowledge generated in this study, planned adaptation is necessary and possible. Its implementation should encourage positive adaptations and discourage negative ones, with boost of the policies to regulate illegal fishing practices, address constraints to adaptation and mitigation with priority given to fishers' proposed interventions and promoting demographic characteristics that enhance diversification. This way, the livelihoods of the fishers will be sustained. However, more research is needed in collaboration with communities in order to prioritize, test and evaluate more adaptations.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study has generated knowledge on how fishers associate perceived floods and droughts to livelihoods, and various adaptation and mitigation measures through which fishers responded to the influence of the perceived floods and droughts. Some of these adaptations and mitigations were beneficial but others could have negative implications for fisheries by enhancing unsustainable fishing, environment degradation and pollution. This knowledge could be used to inform decisions on developing appropriate adaptation and mitigation measures, a process that should involve different interventions to reduce on the constraints that hinder the efforts of the fishers. Adaptation should also be aimed at providing more livelihood opportunities for fishers to reduce their dependence on fishing livelihoods so as to spread their risks and therefore improve capacity to sustain their livelihoods. All these efforts however, should put into consideration interventions to reduce the time constraints of men and women and the differences between men and women observed around Lake Wamala like unequal control of income and other benefits from innovations, which could undermine the success of adaption and mitigation measures and the resilience of the households.

6.2 Recommendations

There is need for efforts to promote the positive adaptation and mitigation measures and to regulate the negative ones and re-align existing policies and make additional ones to address the challenges of the increasing variability and change in climate. For instance, diversification to non-fishery activities which improved the income and food security, and the mitigation measures should be promoted and up scaled.

Studies on the influence of events expected to increase with the increasing climate variability and change are also still in their infancy and more research is needed to determine the direction and consequences of these events on fisheries productivity processes, fish yield and livelihoods, identifying the fishes that are smart enough to persist or adjust to the changed conditions and proposing how they should be managed. This will promote climate smart communities.

Efforts are also needed to build capacity for research and increase awareness in the communities as well as address other constraints preferably by locally driven interventions.

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Appendices

Appendix 1. The semi structured questionnaire for data collection.

This semi structured questionnaire was administered on individual fishers with the overall objective of generating information and data on how climate variability and change had impacted their livelihoods and how the fishers adapt and mitigated the impacts, constraints to adaptation and required interventions. The information collected included:

1. Demographic characteristics of the fishers;
2. Perceptions of fishers on climate variability and change;
3. The livelihoods of the fishers;
4. How the perceived climate events impacted the livelihoods of fishers;
5. How the fishers adapted and mitigated the impact; and
6. The constraints to adaptation and mitigation and the interventions.

1. What are the key geographic and demographic characteristics of the fishers?

Date:
District:
Sub-county:
Landing site:
Tribe:
Sex: [1] Male [2] Female
Age (years):
Marital status: [1] Married [2] Never married [3] Separated/divorced [4] Widowed [999] No response
Number of children:

Total number of people in the household:
Residence: [1] Permanent [2] Temporary
For how long have you stayed here: [1] less than a year [2] 10 years [3] 20 years [3] 30 years [4] 40 years [5] 50 years Others specify
What is your education level: [1] No education [2] Incomplete Primary; [3] Complete primary; [3] Incomplete Secondary; [4] Complete secondary; [5] Tertiary [6] University [7] Others……………... (specify) [999] No response
Membership and types of social group: [1] None; [2] Credit groups [3] Agriculture groups [4] Religious group] [5] Political group [6] Women's group Others ....(specify) [101]Don't know [999] No response
Do you own any of these (assets): [1] Land; [2] House; [3] Bicycle [4] Vehicle [5] Radio [6] Mobile phone [7] Television Others: .... (specify) [101]Don't know [999] No response

2. What are the perceptions of fishers on climate variability and change?

Are you aware of climate variability and change [1] Yes; [2] No; [101]Don't know; [999] No response
Have there been periods of dry and wet seasons within a year?

[1] Yes; [2] No; [101]Don't know; [999] No response
Normally, what are the wet months of the year: Jan; Feb; Mar; Apr; May; Jun; July; Aug; Sept; Oct; Nov; Dec
Normally, what are the dry months of the year: Jan; Feb; Mar; Apr; May; Jun; July; Aug; Sept; Oct; Nov; Dec
Has the timing of dry and wet seasons changed? Yes [1]; No [2]
When were the dry periods with drought?
When were the wet periods with floods?
Has the number of years with drought increased or decreased? Decreased [1]; Increased [2]; No change [3]; Don't know [101]; No response [999]
Has the number of years with floods increased or decreased? Decreased [1]; Increased [2]; No change [3]; Don't know [101]; No response [999]

3. What are the livelihood activities of fishers?

What are the major fishery activities during dry season?: [1] Fishing (......); [2] Renting boat (…..);[3] Renting gear (…..); [4] Fish trading (……); [5] Fish processing (……); [6] Boat crew (……); Others: .... specify [101]Don't know [999] No response
What are the major fishery livelihoods during wet season?: [1] Fishing (......); [2] Renting boat (…..);[3] Renting gear (…..); [4] Fish trading (……); [5] Fish processing (……); [6] Boat crew

(……); Others: .... specify [101]Don't know [999] No response
What have been the target species? [1] Tilapia (……); [2] Catfish (……); [3] Lungfish (……); (4) All (......)
How have the quantities of target species changed over time?: Increase Decrease No change Don't know No response Tilapia Catfish Lungfish
On average, what is the amount of fish caught each fishing trip per species **Wet season** Tilapia _____African Catfish ______ Lungfish___________ **Dry season** Tilapia _____African Catfish ______ Lungfish___________

4. How have perceived floods and droughts impacted livelihoods of fishers?

How did the floods between years impact on fishing? [1] Reduction in fish catches [2] Increase in fish catches [3] Increase in fish size[4] Decrease in fish size [5] Damage to landing sites [6] Damage to boats [7] Damage to gear [8] Loss of lives Others....................... (specify) [101] Don't know [999] No response

How did the drought between years impact on fishing? [1] Reduction in fish catches [2] Increase in fish catches [3] Increase in fish size[4] Decrease in fish size [5] Damage to landing sites [6] Damage to boats [7] Damage to gear [8] Loss of lives Others....................... (specify) [101] Don't know [999] No response
How did floods between years impact on incomes of fishers? [1] Reduced; [2] Increased; [3] No effect [101] Don't know[999] No response
How did drought between years impact on incomes of fishers? [1] Reduced; [2] Increased; [3] No effect [101] Don't know [999] No response
How did floods between years impact on amount of fish consumed? [1] Reduced; [2] Increased; [3] No effect [101] Don't know [999] No response
How did drought between years impact on amount of fish consumed? [1] Reduced; [2] Increased; [3] No effect [101] Don't know [999] No response

5. How have the fishers adapted and mitigated the impacts

What have the fishers practiced in the floods: [1] Migrate (.....); [2] Change fishing gear (......); [3] Use more nets (......); [4] Change target species (......); [5] Revert to non-fishing activities (......); [6] Exit the fishery (......); [7] Changed fishing grounds (......); [8] Increased time on fishing grounds (......) [9] Do nothing (......); Other.. (specify)[101] Don't know [999] No response
What have the fishers practiced in the drought: [1] Migrate (.....); [2] Change fishing gear (......); [3] Use more nets (......); [4] Change target species (......); [5] Revert to non-fishing activities (......); [6] Exit the fishery (......); [7] Changed

fishing grounds (......); [8] Increased time on fishing grounds (......) [9] Do nothing (......); Other.. (specify)[101] Don't know [999] No response
What other livelihoods have fishers diversified to? [1] Crop agriculture [2] Livestock agriculture [3] Non-fishery trading [4] Non-fish employment [5] Fish processing [6] Fish trading Others.. [101] Don't know [999] No response
What crops have the fishers diversified to: [1] Coffee (……);[2] Maize (……); [3] Matooke (……); [4] Cassava (……); [5] Sweet potatoes (……); [6] Tomatoes (……); [7] Pineapples (……); [8] Ground nuts (……); [9] Beans (……); [10] Cabbages (……); [11] Oranges; Others: .... [101] Don't know [999] No response
What livestock have the fishers diversified to: [1] Cattle (No:.......) & (……); [2] Goats (No......) & (……); [3] Pigs (No.....) & (……); [4] Sheep (No:......) & (……); [5] Chicken (No......) & (……); [6] Ducks (No......) & (……); Other............................ [101]Don't know [999] No response
What businesses have the fishers diversified to? [1] Shop (……); [2] Agricultural products; Others................[101]Don't know [999] No response
What employment have fishers diversified to: [1] Paid salary job (……);[2] Casual laborer (…….); [2] Bodaboda (…..): Others [101]Don't know

[999] No response
What do you practice to crop agriculture in the floods: [1] Cultivate early maturing crops (......); [2] Build water harvesting systems (......); [3] Change planting dates (.....); Others...................... (specify)[101]Don't know [999] No response
What do you practice to crop agriculture in the drought: [1] Irrigation (......); [2] Farm near-shore (......); [3] Use drought resistant crops (......); [4] Cultivate early maturing crops (......); [5] Build a water harvesting systems (......); [6] Change planting dates (.....); Others....................... (specify)[101]Don't know [999] No response
What do you practice to livestock agriculture during the floods: [1] Sell animals (......); [2] Zero grazing (......); [4] Fodder production (.......); Others………….. specify [101]Don't know [999] No response
What do you practice to livestock agriculture in the drought: [1] Sell animals (......); [2] Zero grazing (......); [3] Graze in wetlands (.....); [4] Fodder production by irrigation (.......); [5] Buy feed supplements (......); [6] Diversify farmed animals; Other............... (specify)[101]Don't know [999] No response
What measures are you involved in reducing impact of climate change and what is their relative importance? [1] Plant trees (......); [2] Protect wetlands & riparian zones (......); [3] Mulch gardens (......); [4] Others.............................. (specify)[101]Don't know [999] No response

6. What are the constraints to adaptation and mitigation and the interventions to overcome them?

What constraints do you face in adapting to and reducing the impact of climate change? [1] Limited awareness; [2] Limited land; [3] Lack of credit facilities; [5] Inadequate enforcements of laws; [6] Lack of appropriate planting materials; Others:...............................specify[101]Don't know [999] No response
Can you suggest some interventions to overcome the constraints? [1] Increase awareness; [2] Enforce laws and regulations; [3] Provide low interest credit; [4] Provide irrigation pumps;[5] Provide planting materials; Others...............[101]Don't know [999] No response

Appendix 2. Focus group discussion guide questions.

This tool comprises of questions which facilitated different focus group discussions of men and women to generate information on: livelihood activities of men and women and benefit analysis flow chart to assess the benefits from diversification for both men and women.

Background information

Landing site	
Date	
Time taken	

Focus group discussion members (insert number of participants)

Age group	Female	Male

Examining livelihood activities of men and women and daily activity clocks	**Notes**
What are the major livelihood activities of men and women (e.g. Fishing, crop production, livestock production, sowing, harvesting, ploughing, wood harvesting, fish processing, fish trading. others specify	
Who is responsible for the agriculture activities? – [1]Men, [2]women or a[3] Both	
What are the major non-agriculture livelihood activities of men and women? [1]fuel collection, [2]water collection, [3]children care, [4]cooking, [5]others specify)	

Who controls the income from the different activities? [1]Men, [2] women or [3] Both?	
Who is responsible for or spends time on the non-agriculture activities? – [1] Men, [2]women or a[3] Both?	
What are the other major income-generating activities and who carries them out (e.g. marketing, waged labour)?	
Which activities and resources contribute most to meeting the basic needs of the household?	
Which households have most diversified livelihoods? Which are most vulnerable, depending on only one or two activities or resources?	
How is women's and men's time divided	
For each person, how is their time divided? How much time is devoted to productive activities? domestic activities? community activities? leisure? sleep? How do they vary by season?	
Benefits Analysis-benefits from innovations (diversification to crop and livestock agriculture for men and women)	
What have been the reasons for diversification? 1. Income (.........); 2. Food security (.......); 3. Employment (........) others specify	
How have you benefited from crop agriculture? Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....)	
How have you benefited from livestock agriculture Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....)	

Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....)	
How are the benefits from diversification used?	
Which benefits from diversification are controlled by men? by women?	
Who decides on their use, who does it?	
If sold, how is the cash used? Who decides on cash use?	

Appendix 3. Income and benefits from fishing and diversification to non-fishery activities.

Name of respondent: ______________________Village/Landing site: Sex [M], [F]; Age:

____

What are the major fishery activities?: [1] Fishing (......); [2] Renting boat (…..);[3] Renting gear (…..); [4] Fish trading (……); [5] Fish processing (……); [6] Boat crew (……); Others: .... specify; [999] No response What is the estimated income from different activities per week: [1] Fishing (................); [2] Renting boat (...............);[3] Renting gear (….............); [4] Fish trading (…….............); [5] Fish processing (…….........); [6] Boat crew (……............); Others: .... specify
What livelihoods have fishers diversified to? [1] Crop agriculture [2] Livestock agriculture [3] Non-fishery trading [4] Non-fish employment [5] Fish processing [6] Fish trading Others...[999] No response
What crops have the fishers diversified to: [1] Coffee (……);[2] Maize (……); [3] Matooke (……); [4] Cassava (……); [5] Sweet potatoes (……); [6] Tomatoes (……); [7] Pineapples (……); [8] Ground nuts (……); [9] Beans (……); [10] Cabbages (……); [11] Oranges; Others: .... [999] No response What have been the reasons for diversification?: 1. Income (.........); 2. Food security (.......); 3. Employment (........) Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....)

Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) By how much has income increase per year compared to fishing? [number of time e.g. ten time]: (.......) What is the income from crops per season in UShs? (..).
What livestock have the fishers diversified to: [1] Cattle (No:......) & (……); [2] Goats (No......) & (……); [3] Pigs (No.....) & (……); [4] Sheep (No:......) & (……); [5] Chicken (No......) & (……); [6] Ducks (No......) & (……); Other............................ [999] No response What have been the reasons for diversification?: 1. Income (.........); 2. Food security (.......); 3. Employment (........) Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) By how much has income increase per year compared to fishing? [number of time e.g. ten time]: (.......) What is the income from livestock/poultry year in UShs? (...).
What businesses have the fishers diversified to? [1] Shop (……); [2] Agricultural products; Others................ [999] No response What have been the outcome of diversification?: 1. Income (.........); 2. Food security (.......); 3. Employment (........) Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....)

Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) By how much has income increase per year compared to fishing? [number of time e.g. ten time]: (.......) What is the income from trade per month in UShs? (.......................................).
What employment have fishers diversified to: [1] Paid salary job (……);[2] Casual laborer (…….); [2] Bodaboda (…..): Others [101]Don't know [999] No response What have been the outcome of diversification?: 1. Income (.........); 2. Food security (.......); 3. Employment (........) Has the income: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has food security: [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) Has employment [1]. Increased (......); 2. Decreased: (......); 3. Not changed: (.....) By how much has income increase per year compared to fishing? [number of time e.g. ten time]: (.......) What is the income from employment per month in UShs? (.......................................).

Appendix 4. Descriptions of the predictors and how they were expected to influence diversification.

Variable/Predictor	Influence of the predictor
Age	(total years of household head) has positive and negative relationships with adoption of agriculture technologies (Shiferaw & Holden, 1998; Sahu & Mishra, 2013) and was expected to either enhance or limit diversification.
Marital status	Marital status was whether the house head was married or not. Male headed households were expected to easily access new technologies and undertake risky activities (Asfaw & Admassie, 2004) thus more likely to diversify. Women control agricultural activities (Nhemachena & Hassan, 2007) and these attributes combined could boost diversification among married fishers.
Household size	Household size was the total members in a household. Large households divert labor to various activities to provide for their needs (Yirga, 2007) and were expected to increase diversification.
Education	Education was whether the household head had attained a certain level of formal education or not. Education is associated with the ability to access and utilize information and adoption of technologies (Daberkow& McBride, 2003) and was expected to enhance diversification.
Membership to social groups	Membership to social groups determined whether the household head belonged to social groups like credit and religious groups which provide communities with sense and purpose to adapt and was expected to enhance diversification and in some cases capital.
Knowledge of	Knowledge of timing of season was whether the head was aware of when

Variable/Predictor	Influence of the predictor
timing of season	seasons occur. For communities to adapt, knowledge of variations or changes in climate is important and was expected to enhance diversification.
Use of communications technology	Use of communications technology was whether the head used telephone and radios or not. Access to information is a key determinant of technology adoption behavior of communities engaged in agricultural activities (Yirga, 2007). Extension is increasingly becoming tailored to technology and this was expected to enhance diversification.
Weekly fishing days	Weekly fishing days in a season were the days the head fished weekly in the dry and wet seasons. Increasing fishing days was expected to limit diversification as this would reduce on the time devoted to non-fishing activities.
Fishing experience	Fishing experience was the number of years spent fishing. Experience increases probability of uptake of adaptation measures (Nhemachena& Hassan, 2007) and was expected to enhance diversification.
Residence status	Residence status was whether a household was permanently living around the lake or migratory. Most migratory fishing communities do not participate in non-fishery activities limiting diversification while permanent residence execute long term and land based activities which enhances diversification.

Appendix 5. Data entry and analysis format

Data was entered in a separate spreadsheet for each research question for analysis as illustrated below for some geographic and demographic characteristics.

SN	Date	District	Sub County	Village	Landing site	Tribe	Sex	Age	Marital. Status	Household size	Residence status	Education. level	Membership to social groups	Type of Social group
1														
2														
3														
4														
5														
6														
7														
8														
9														

Appendix 6. Frequency of dry and wet months as perceived by fishers around Lake Wamala.

Months	Wet	Dry
January	5	43
February	14	22
March	33	8
April	47	1
May	23	12
June	3	47
July	2	55
August	28	17
September	33	3
October	38	1
November	37	1
December	42	3

Appendix 7. Relative proportion (%) of perception of fishers around Lake Wamala on occurrence of droughts and floods.

Perceptions	Droughts	Floods
Decreased	68.5	48.1
Increased	20.4	40.7
No change	3.7	3.7
Did not know	7.5	7.4

Appendix 8. Time series (1970-2012) annual mean minimum and mean maximum temperature anomalies (^{o}C) for Mubende weather station near Lake Wamala, calculated as departures form the 1981 to 2010 average.

Year	Mean maximum temperature anomaly (^{o}C)	Mean minimum temperature anomaly (^{o}C)
1970	2.1671	-0.1142
1971	2.3088	-0.799
1972	2.1005	0.0864
1973	2.4921	-0.0823
1974	2.5505	-0.6433
1975	2.3755	-0.2767
1976	1.9255	-0.0579
1977	-0.8747	0.1496
1978	-0.8162	-0.0208
1979	-0.4079	-0.1375
1980	0.0671	0.1125
1981	0.0338	-0.1041
1982	0.2588	0.2959
1983	0.3338	0.4542
1984	0.2788	2.00E-03
1985	-0.3162	-0.4375
1986	-0.0412	-0.6291
1987	-0.9912	-0.3041
1988	-0.4194	-0.1713
1989	-0.4309	-0.1827
1990	-0.4495	0.4292
1991	-0.2162	0.3625
1992	0.6005	-0.4291
1993	0.4755	-0.1125
1994	0.0903	0.2909
1995	0.3234	-0.1883
1996	-0.2479	-0.1804
1997	0.1247	-0.6516
1998	-8.16E-03	-0.1865
1999	-0.5018	-0.6063
2000	-0.9793	-0.4626
2001	-0.414	-0.1255
2002	0.3951	-0.143
2003	0.2077	0.0313
2004	0.3002	-0.18
2005	1.1338	0.0292
2006	0.2255	0.2209
2007	0.3398	0.3733

Year	Mean maximum temperature anomaly (°C)	Mean minimum temperature anomaly (°C)
2008	0.2183	-0.0282
2009	-1.0329	1.9042
2010	0.7088	0.7292
2011	0.9171	0.2875
2012	-0.2412	1.6292

Appendix 9. Time series (1970-2012) annual rainfall anomalies (mm) and SPI for Mubende weather station near Lake Wamala, calculated as departures from the 1981 to 2010 average.

Year	Rainfall anomaly (mm)	SPI
1970	-195.38	-1.0321
1971	-123.98	-0.6549
1972	-356.18	-1.8816
1973	-286.18	-1.5118
1974	-360.98	-1.9069
1975	-221.18	-1.1684
1976	-7.884	-0.0416
1977	414.316	2.1886
1978	189.216	0.9995
1979	-263.18	-1.3903
1980	-136.58	-0.7215
1981	-344.48	-1.8197
1982	-91.384	-0.4827
1983	-219.48	-1.1594
1984	-46.284	-0.2445
1985	-232.08	-1.226
1986	-229.98	-1.2149
1987	-188.28	-0.9946
1988	464.616	2.4543
1989	20.816	0.11
1990	99.016	0.5231
1991	-188.98	-0.9983
1992	-137.38	-0.7257
1993	-161.68	-0.8541
1994	28.116	0.1485
1995	71.916	0.3799
1996	23.216	0.1226
1997	203.516	1.0751
1998	55.316	0.2922
1999	-11.284	-0.0596
2000	116.716	0.6166
2001	238.316	1.2589
2002	176.916	0.9346
2003	282.616	1.4929

Year	Rainfall anomaly (mm)	SPI
2004	-89.884	-0.4748
2005	-208.27	-1.1002
2006	52.816	0.279
2007	9.516	0.0503
2008	-137.78	-0.7278
2009	157.316	0.831
2010	286.516	1.5135
2011	116.816	0.6171
2012	234.016	1.2362

Appendix 10. Monthly average rainfall (mm) for Mubende weather station near Lake Wamala averaged for the years 1970-2012.

Months	Average rainfall
January	51.7605
February	52.9163
March	122.6421
April	130.2163
May	104.6279
June	54.8209
July	54.0651
August	88.9372
September	117.8558
October	145.0814
November	145.7465
December	85.8233

Appendix 11. Relative proportions (%) of fishery livelihoods during the dry and wet seasons for fishers around Lake Wamala.

Livelihood	Dry season	Wet season
Fishing	81.3559	78.6885
Fish trading	11.8644	14.7541
Renting gear	3.3898	3.2787
Renting boat	3.3898	3.2787

Appendix 12. Relative importance (%) of different target fish species for fishers around Lake Wamala.

Species	Relative importance (%)
Nile tilapia	27.4407
African catfish	38.6316
Lungfish	33.9276

Appendix 13. Relative proportions (%) of perceived changes in quantities of target fish species by the fishers around Lake Wamala.

Perception	Nile tilapia	African catfish	Lung fish
Decreased	52.1	38.7	66.7
Increased	43.8	58.1	31.5
No change	4.2	3.2	1.9

Appendix 14. Catch composition (%) of target fish species of Lake Wamala.

Year	Nile tilapia	African catfish	Lung fish	Others
1999	90	5	4	1
2000	89	8	3	0
2012	20	43	25	12
2013	2	73.4	15	9.6

Appendix 15. Relative dominance (%) of targeted fish species during flood and drought periods by fishers around Lake Wamala.

Species	Floods	Droughts
Nile tilapia	17.3	40
African catfish	71.2	32
Lung fish	11.5	28

Appendix 16. Relative proportions (%) of perceived impacts of floods and droughts on income from fishing around Lake Wamala.

Impact	Floods	Droughts
Decreased	52	45.1
Increased	34	41.2
Did not know	8	7.8
No response	6	5.9

Appendix 17. Relative proportions (%) of perceived impacts of floods and droughts on fish consumption around Lake Wamala.

Impact	Floods	Drought
Increased	50	30
Decreased	28	42
No effect	12	14
Did not know	6	8
No response	4	6

Appendix 18. Relative proportions (%) of the non-fishery livelihood activities diversified to by the fishers around Lake Wamala.

Livelihoods	Relative proportion
Crop agriculture	45.4545
Livestock agriculture	36.3636
Trading	11.1111
Informal employment	3.0303
None	4.0404

Appendix 19. Relative proportions (%) of different crops grown by fishers around Lake Wamala.

Crop	Relative proportion (%)
Cassava	17.1
Maize	16.2
Sweet potatoes	19
Tomatoes	9
Beans	15.2
Ground nuts	2.4
Cabbages	1.4
Coffee	6.2
Matooke	11.9
Irish potatoes	1.4

Appendix 20. Relative proportions (%) of livestock and poultry of the fishers around Lake Wamala.

Livestock	Relative proportion (%)
Cattle	4.918
Chicken	24.5902
Goats	16.3934
Pigs	49.1803
Ducks	1.6393
Sheep	3.2787

Plates

Plates 1. Some of the high value crops; pineapples (a), cabbages (b) and livestock; pigs (c) that fishers or former fishers around Lake Wamala acquired (Source: NaFIRRI archives).

a b c

Plates 2. A former fisher displays abandoned gillnets hanged on a tree (a) and his pineapple plantation (b) and a vehicle he acquired (c) (Source: NaFIRRI archives).

a b c

Plates 3. A fisher, who diversified to crop and livestock farming which enabled him increase his income as seen at work (a), his poultry farm (b) and on a motorcycle he acquired (c) (Source: NaFIRRI archives).

a b c

Plates 4. Illustration of different irrigation measures used by fishers around Lake Wamala during the dry season and drought (a: watering can; b: simple can; c: mechanical pump (Source: NaFIRRI archives).

· a b c